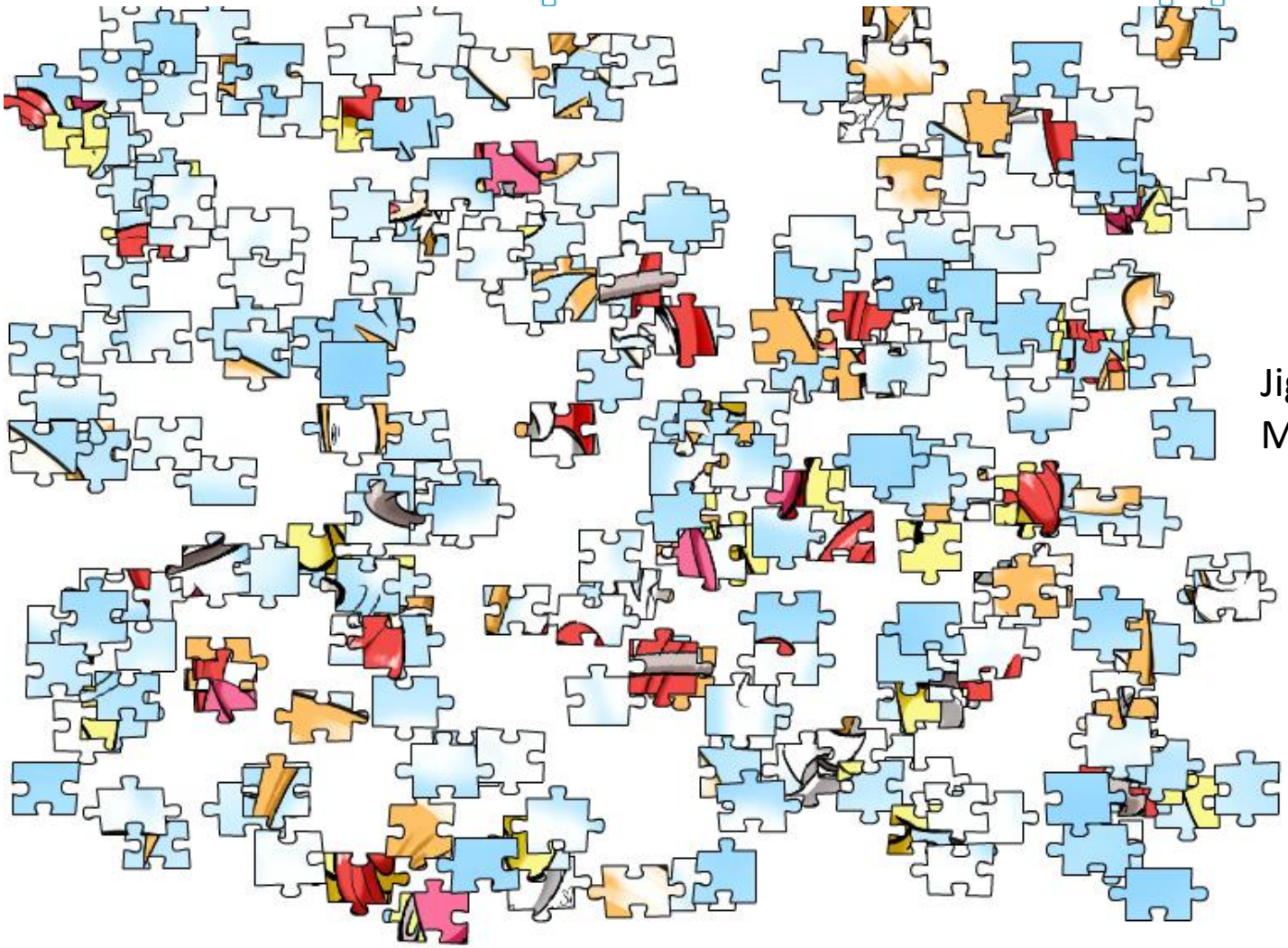
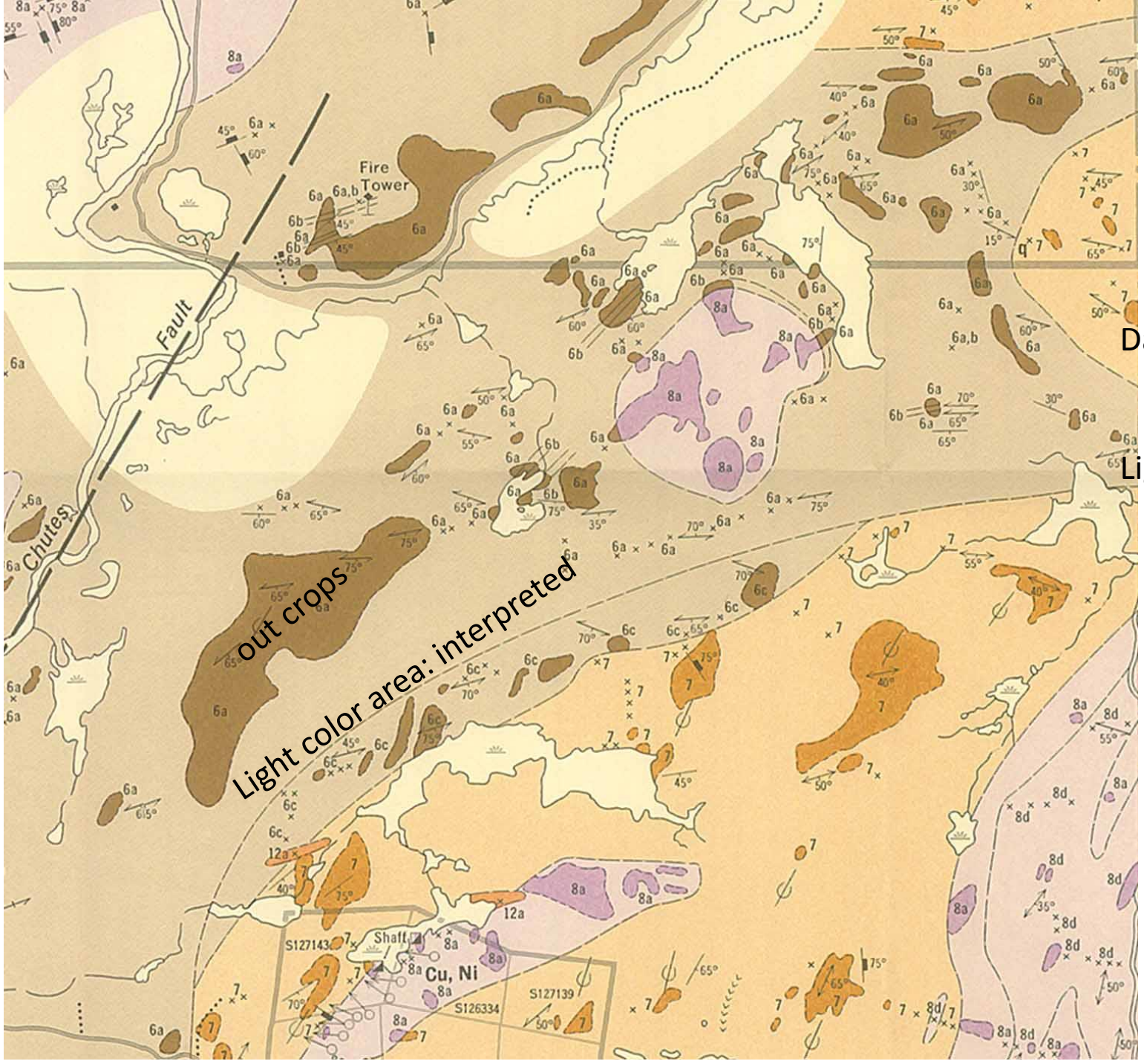
Some practical applications of Structural Geology

Application example 1: Data interpretation in mapping

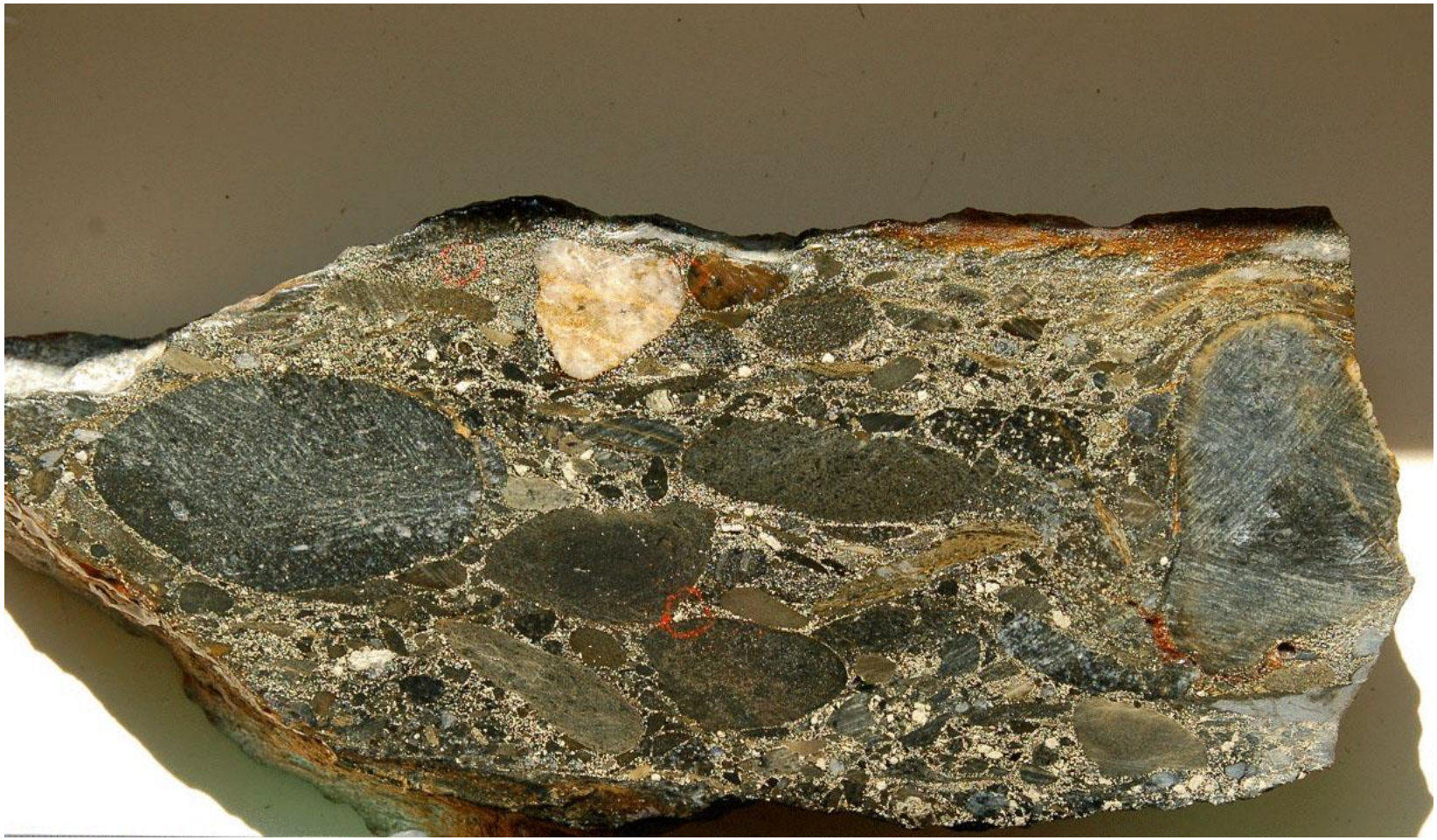


Jigsaw puzzle;
Many pieces are missing;



Dark color area:
Mapped outcrops; Observation
Light color:
interpreted

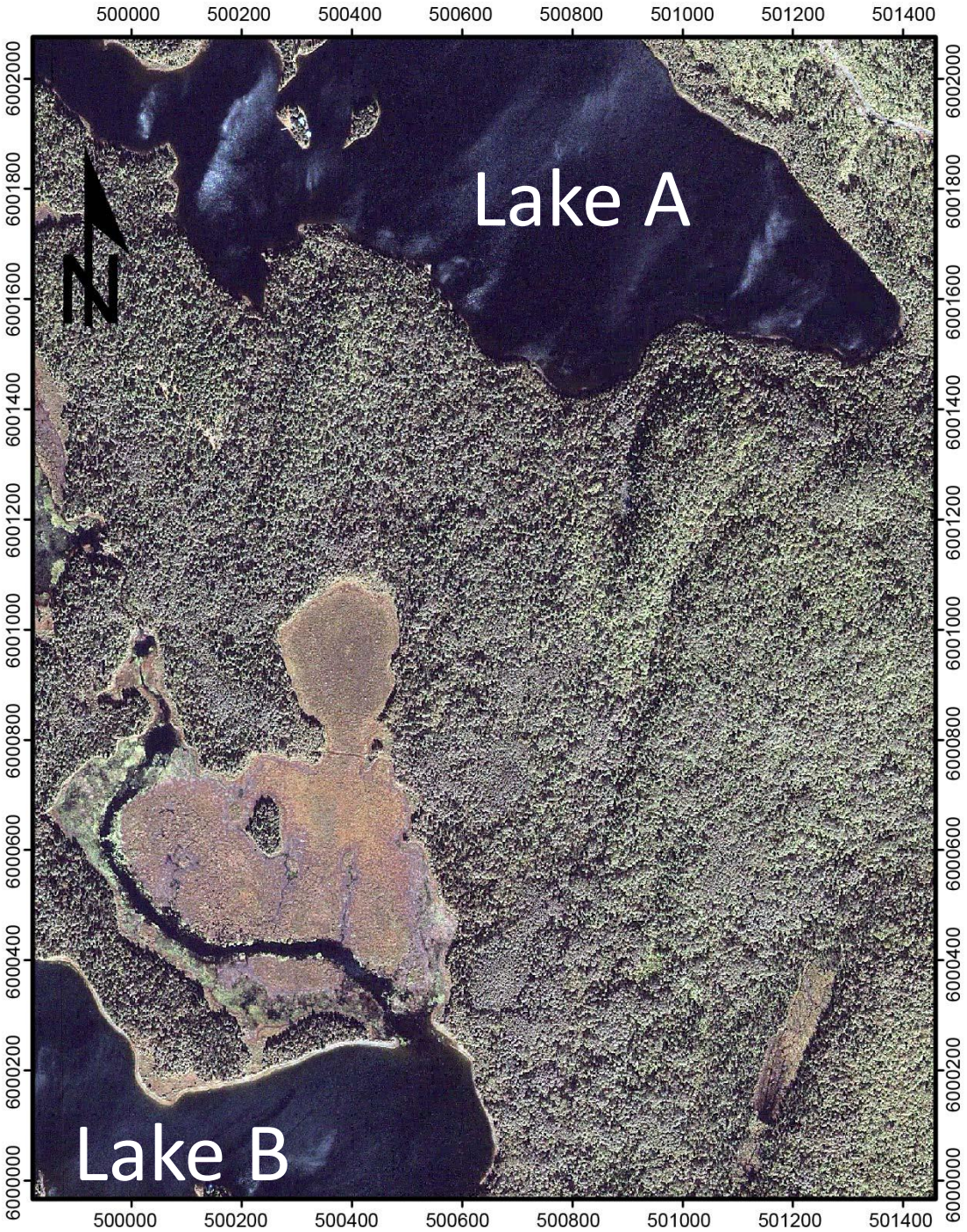
Mapping; Placer gold; Conglomerate



Placer gold: Associated with pyrite and conglomerate

gravity separation (sorting)

Look for gold: Distribution of conglomerate; geological mapping

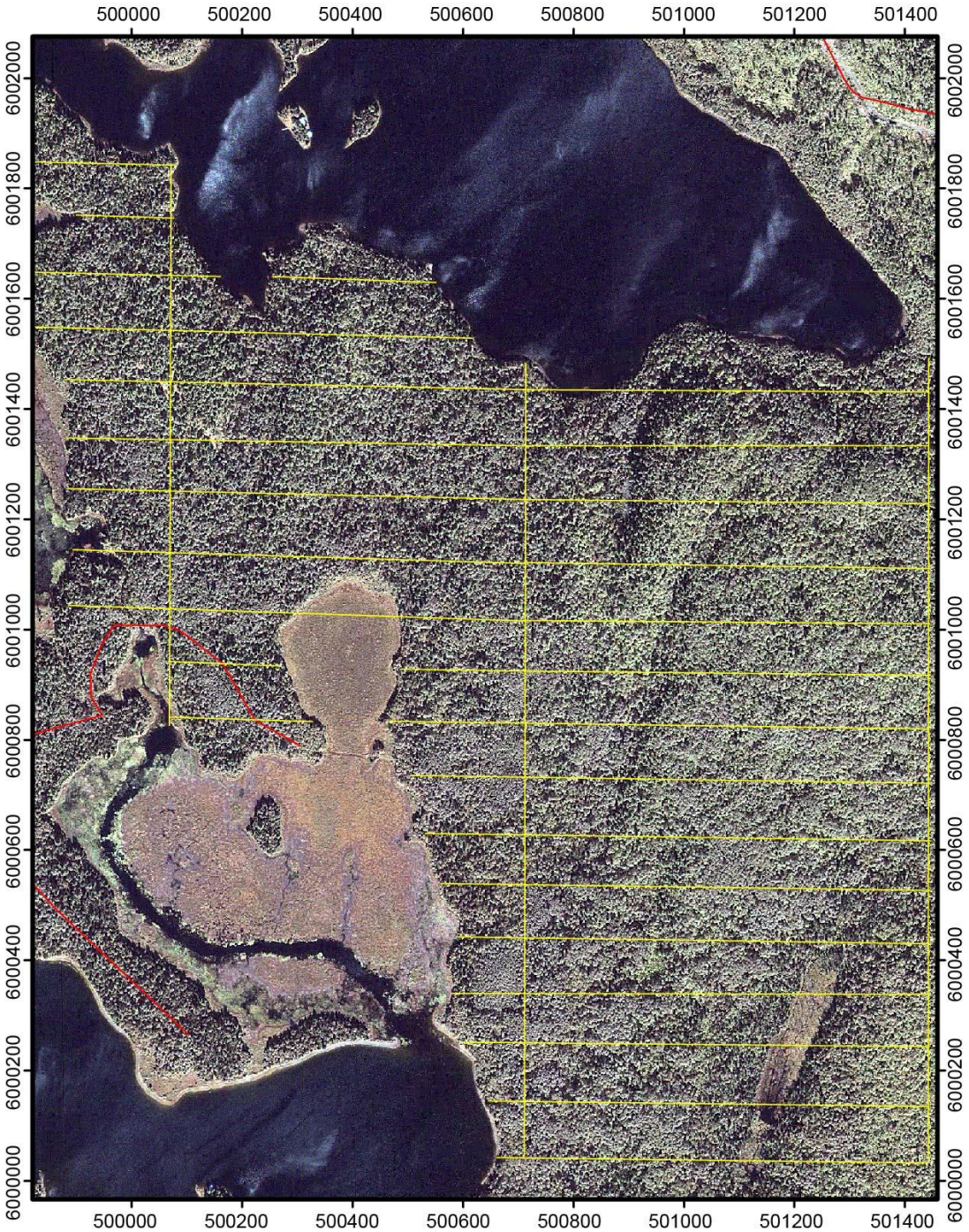


Coordinate

Airphoto interpretation

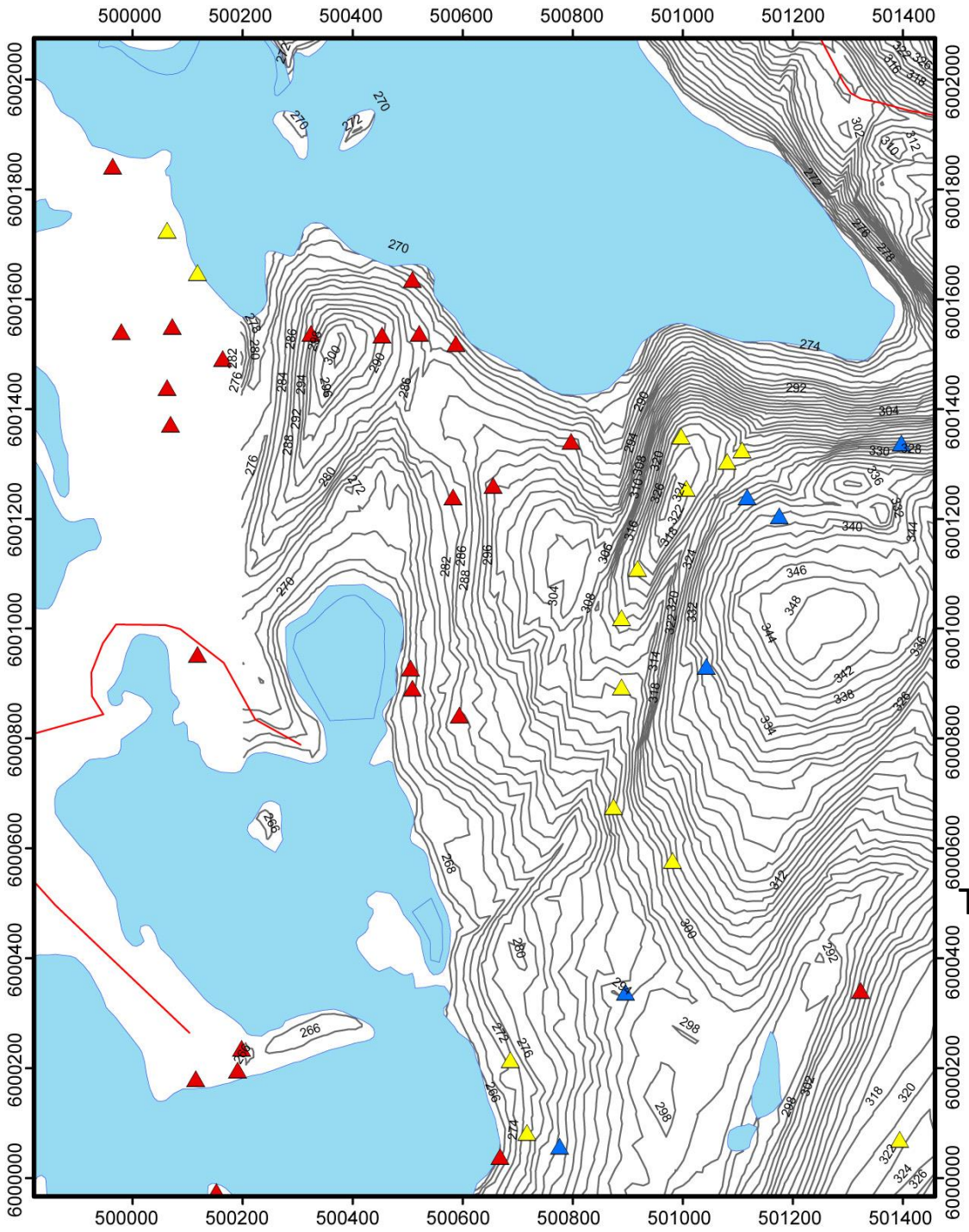
Outcrop

Limited outcrops



Yellow: Cutline
Red: Trail

Hired local people to use chainsaws to cut grid lines



Mapping data:

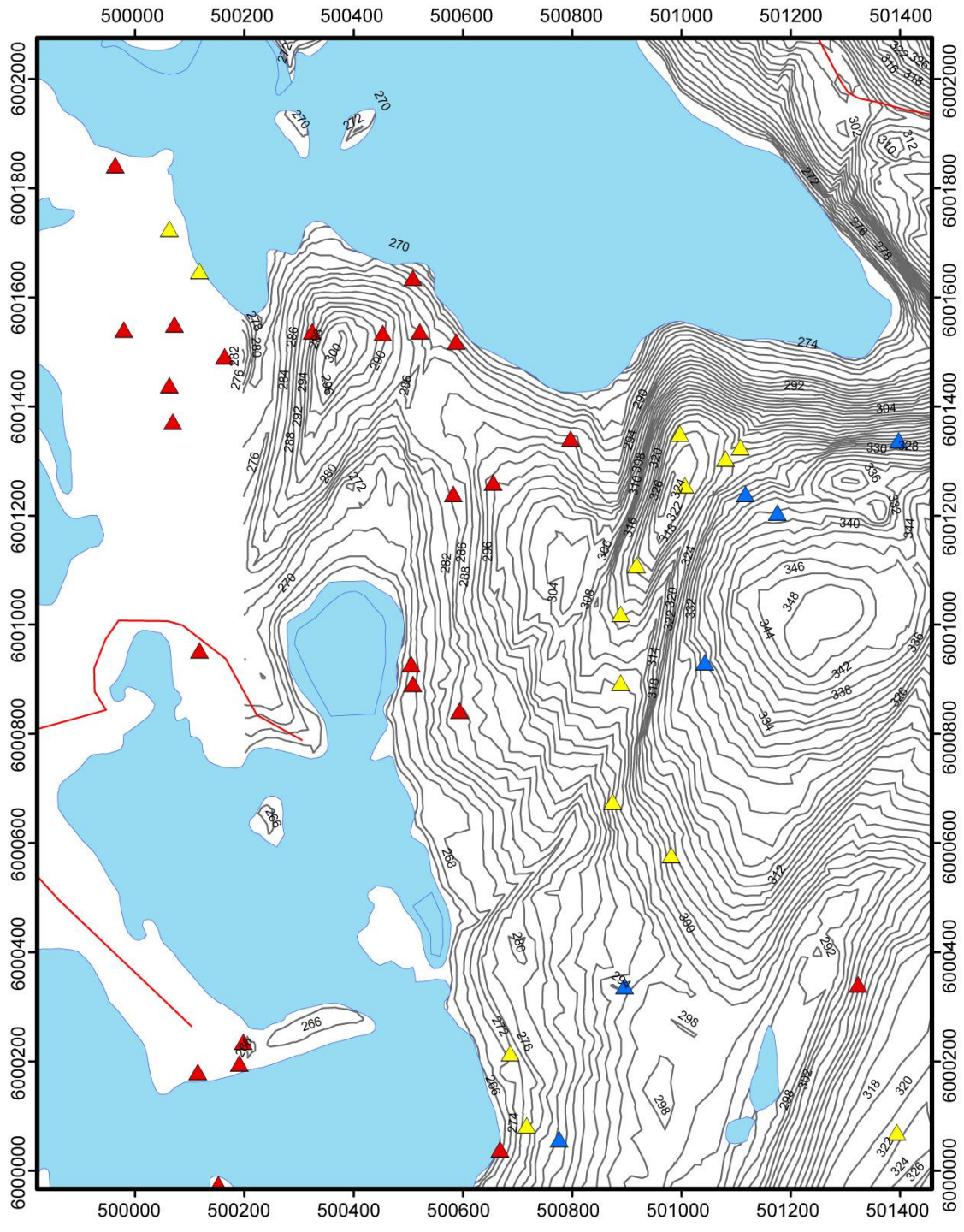
Triangles are outcrops

Yellow triangles:
massive sandstone

Blue triangles:
massive diabase
(Igneous intrusion;
Nipissing diabase)

Topographic contour lines

Field photo of outcrops indicated by red triangles in the last slide

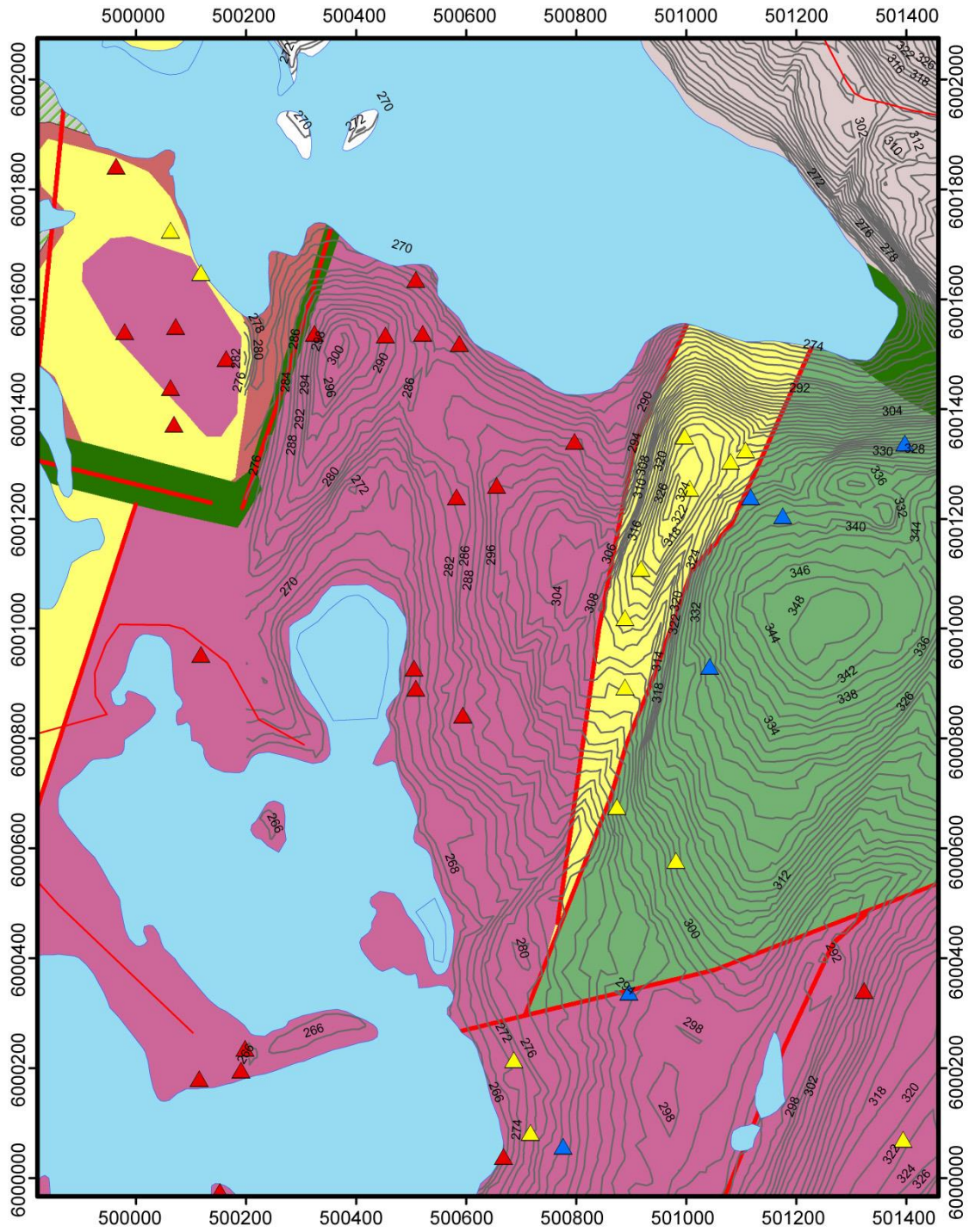


Field data:

- Yellow triangles: massive sandstone
- Blue triangles: massive diabase (Igneous intrusion)

If you map this area, how are you going to draw the map?

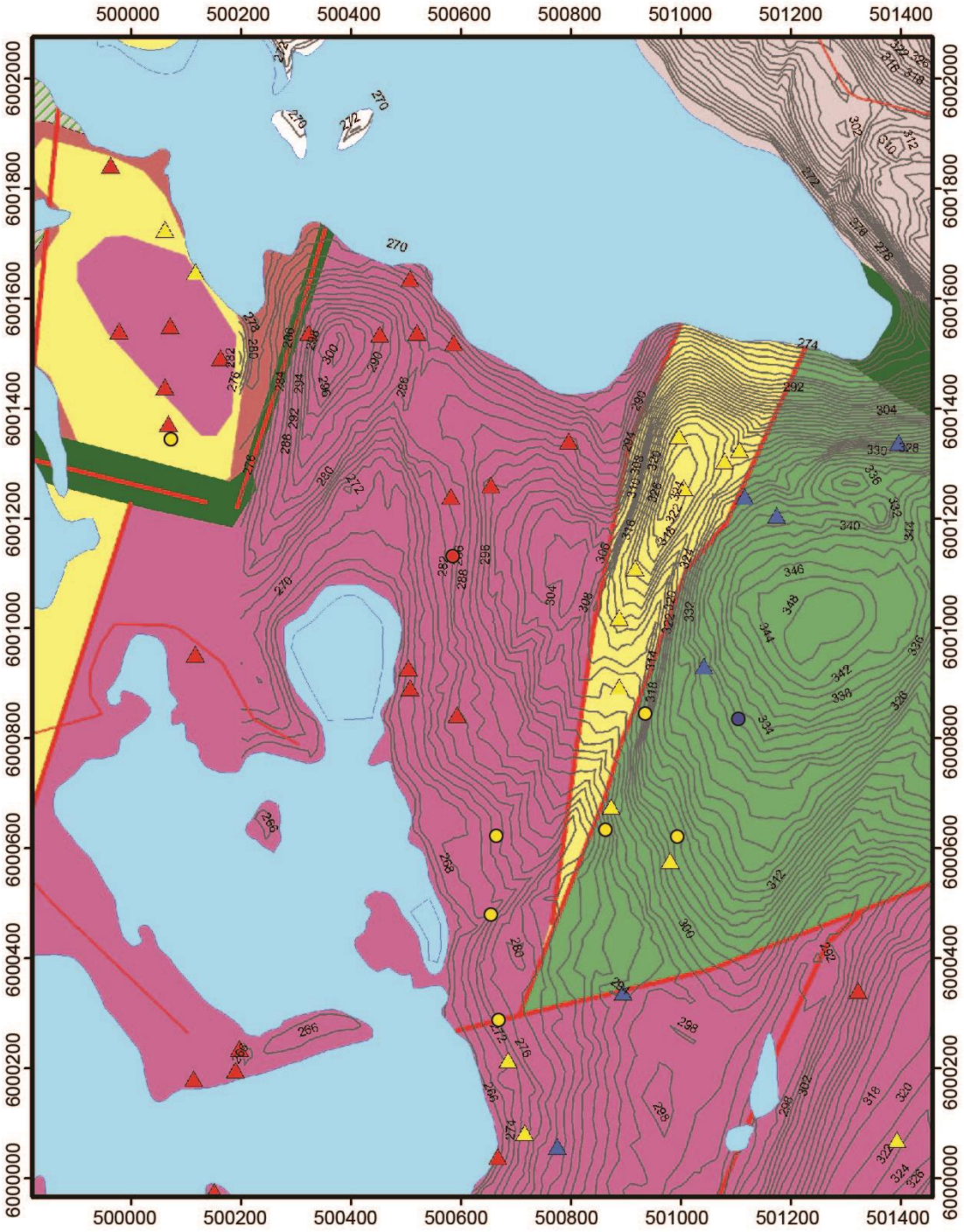
If you think more data are needed, which area would like to visit?



Interpretation by geologist A:

- Lithology is controlled by faults.
- Faults are interpreted based on topography

Do you agree with this geologist?

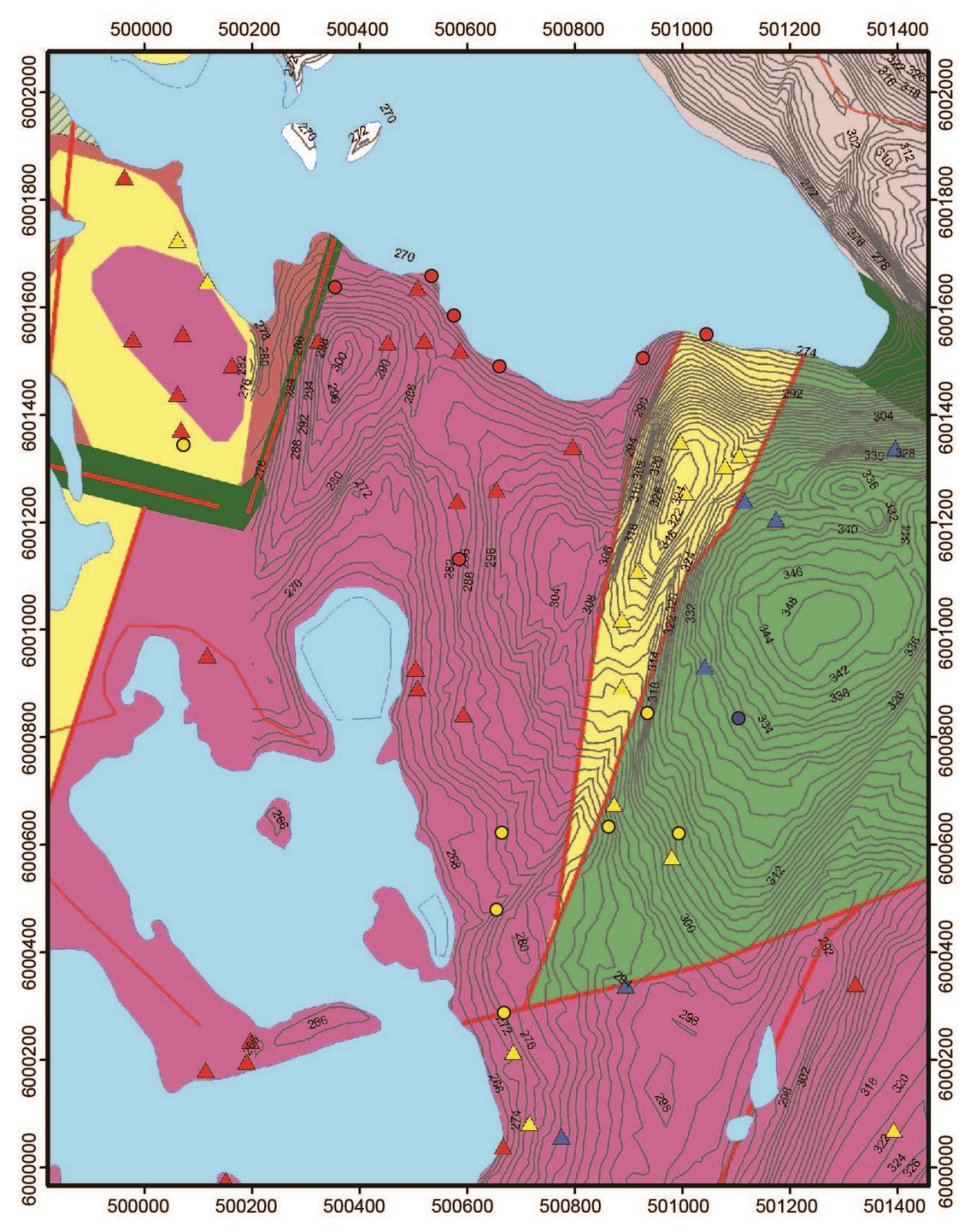


Sandstone and conglomerate belong to the same sedimentary formation.

//

New data: solid circles
Red: conglomerate
Yellow: sandstone

Vertical face: Conglomerate and sandstone
Horizontal bedding



New Data Collected

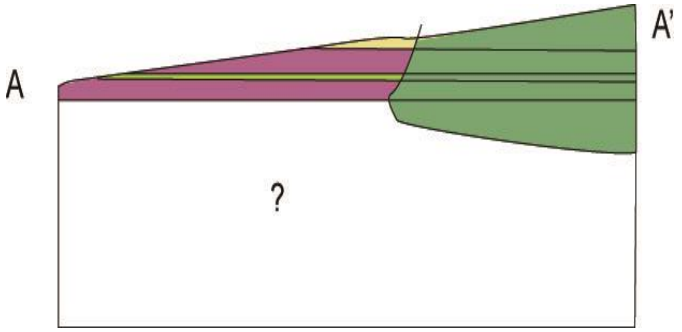
Yellow: sandstone

Blue: massive diabase (Igneous intrusion)

New data conflict with the map (interpretation by geologist A)

New interpretation?

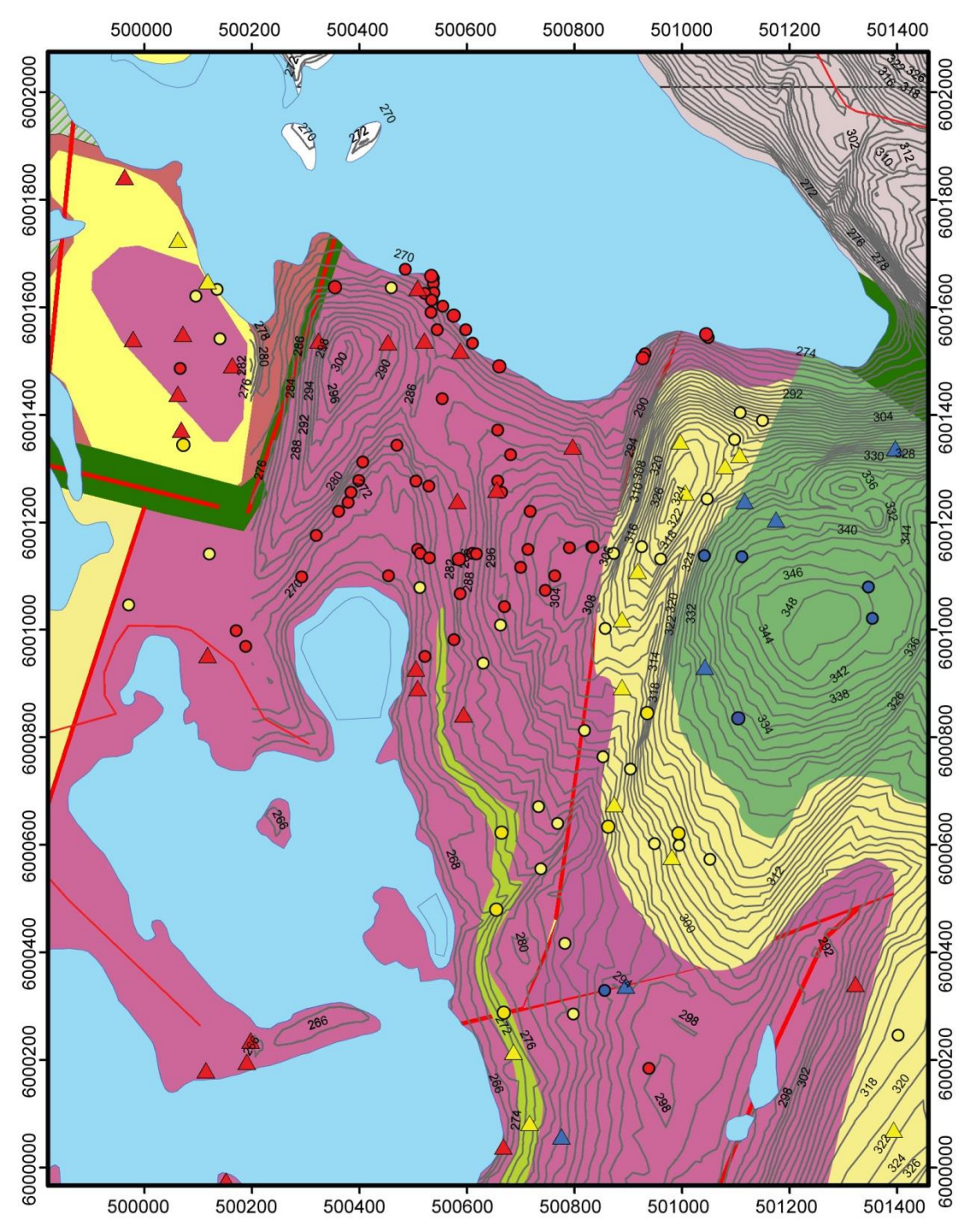
Interpretation by geologist B:



Horizontal scale?
Vertical scale?

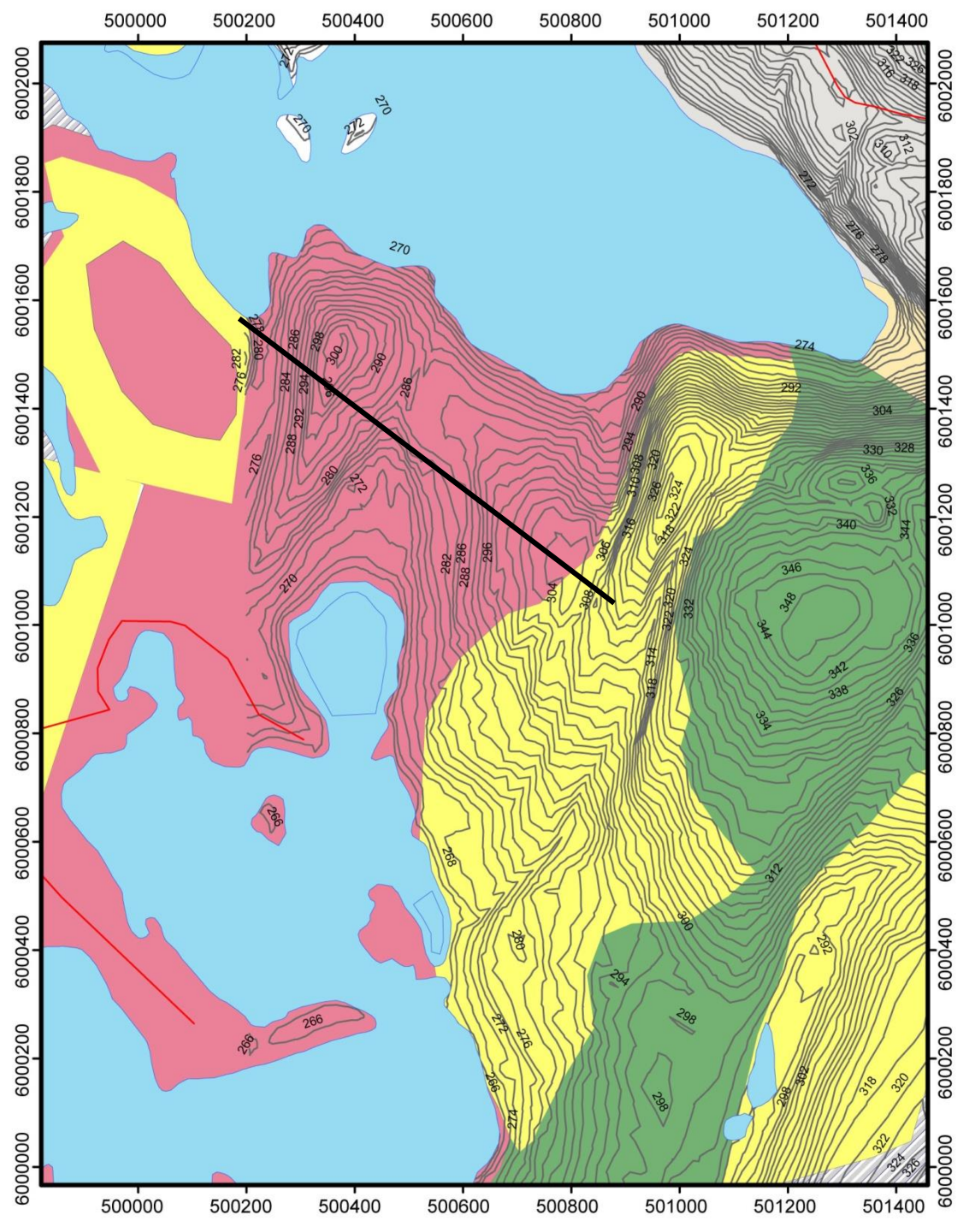
Thin sandstone layer within conglomerate

May not right, but explains all the data collected.



More field work

Interpretation
model conflicts
with new data



New Interpretation:

- Conglomerate in a SSW-trending channel

Bottom of conglomerate

Summary of Example 1

- Mapping: understanding of available data
- Model-more data-new model
- May never know

Application example 2: Stratigraphic sequence based on borehole data

Drill hole #1 (Vertical):

0-44m massive sandstone

44-50.73m Conglomerate (Top/base subhorizontal)

50.73-81.64m Mudstone

81.64-128m sandstone

128-131m conglomerate

131-144m mudstone (base: subhorizontal)

144-154.5m Foliated (vertical foliation) metasediment in basement

Bedding in mudstone

Steeply dipping

Deformation Structures

•Fault gauge
• fault breccia
• Foliation

Application 2: Stratigraphic sequence based on borehole data

Drill hole #1 (Vertical):

Structures:

At 68m bedding is recognized. Dip: 60 degree

87m Dip: 15

138m Dip: 10

At 78.84-81.64m Fault (fault plane dip: around 60 degree; striation is along dip line) is recognized.

Contact of mudstone&basement: subhorizontal

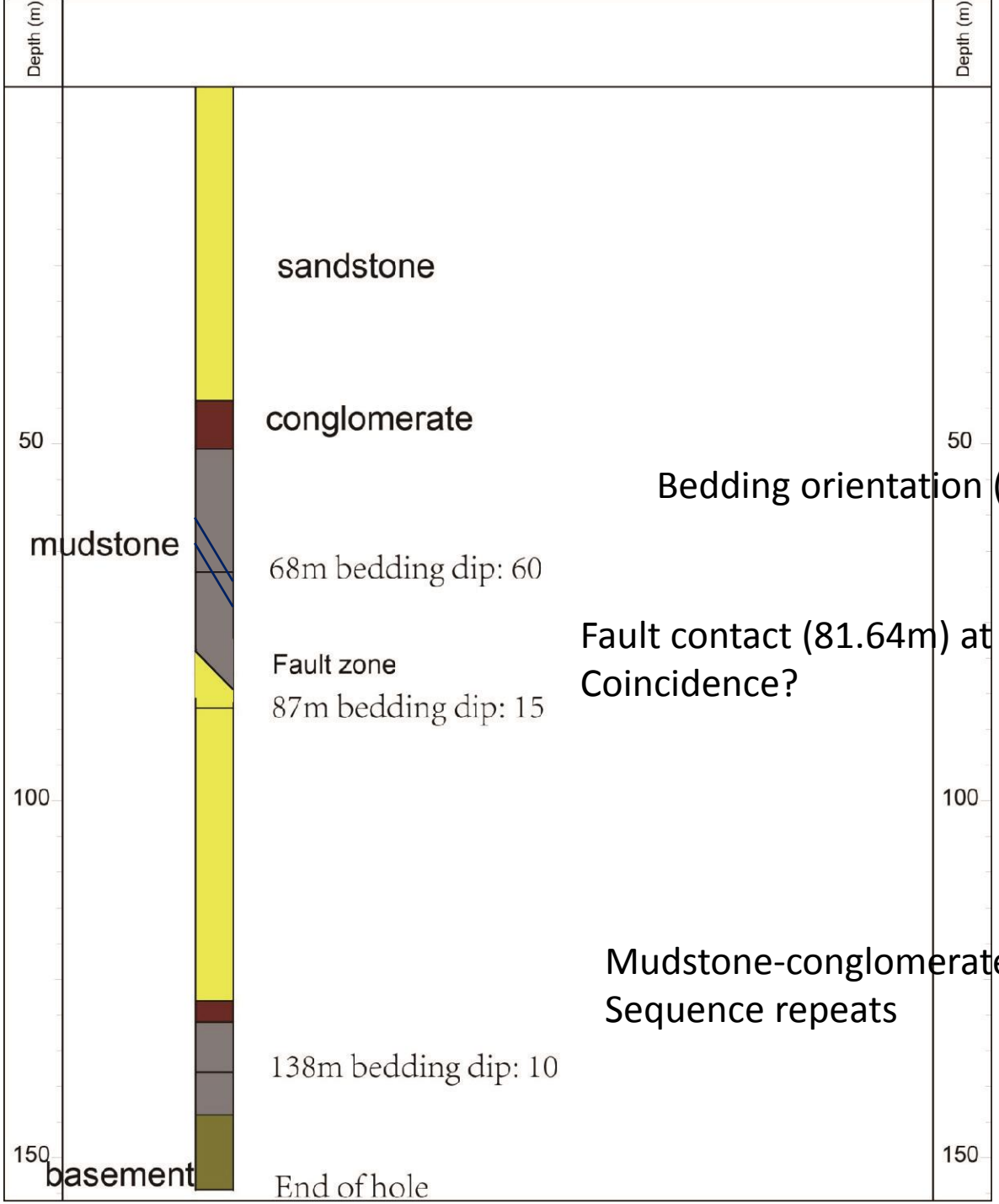
Other drill holes nearby all show subhorizonal bedding.

Draw the drill section

What is the stratigraphic sequence of the area based on the information from the core log?

What is the geological history?

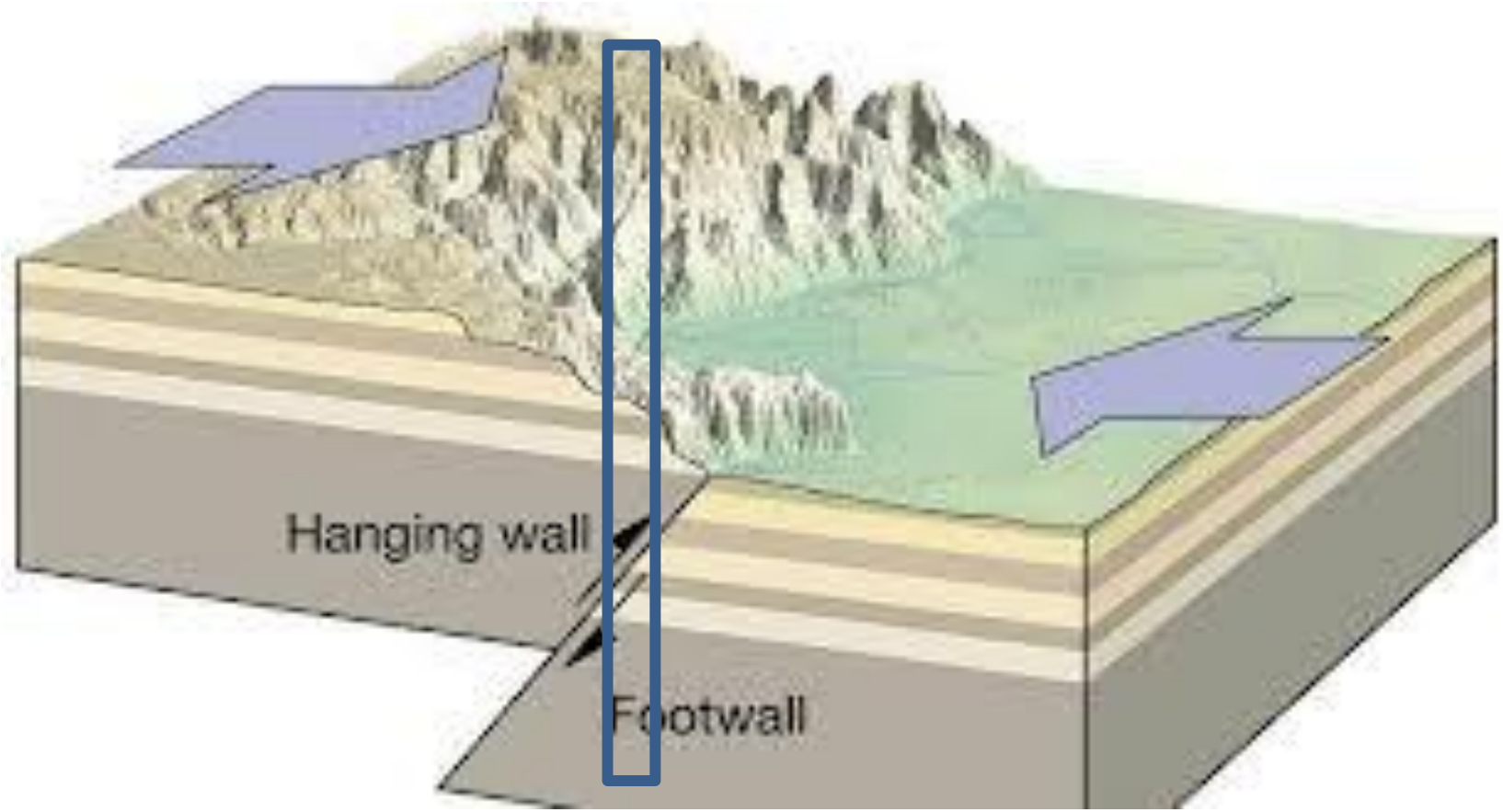
What type of fault is it?



Bedding orientation (Dip) varies

Fault contact (81.64m) at unit boundary.
Coincidence?

Mudstone-conglomerate-sandstone
Sequence repeats

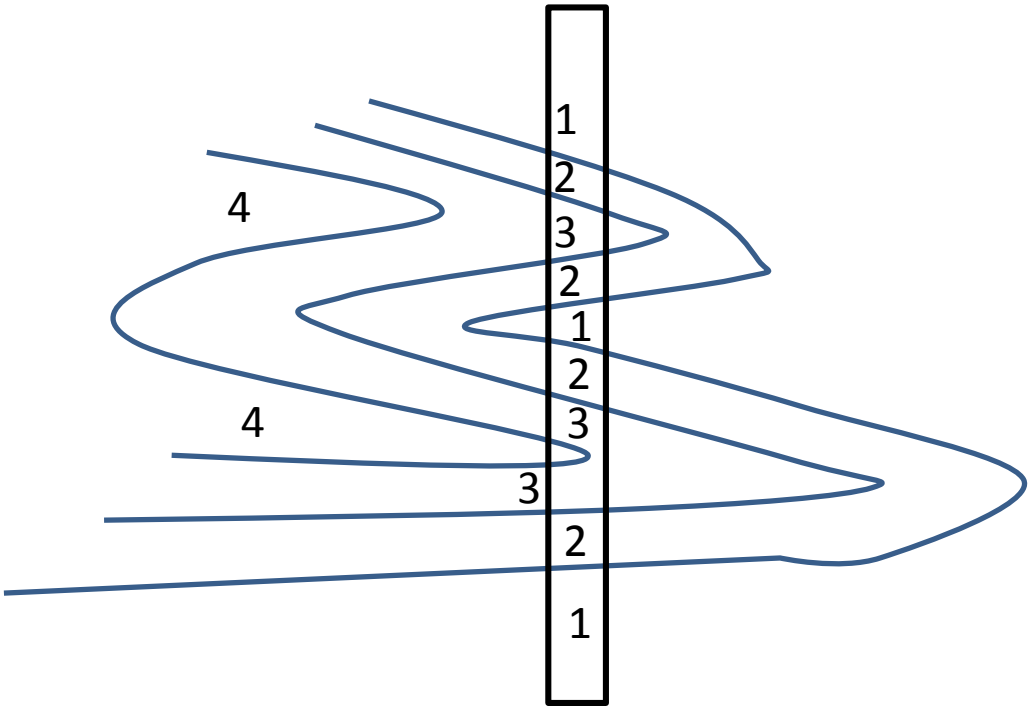


From internet

Sequence repeats

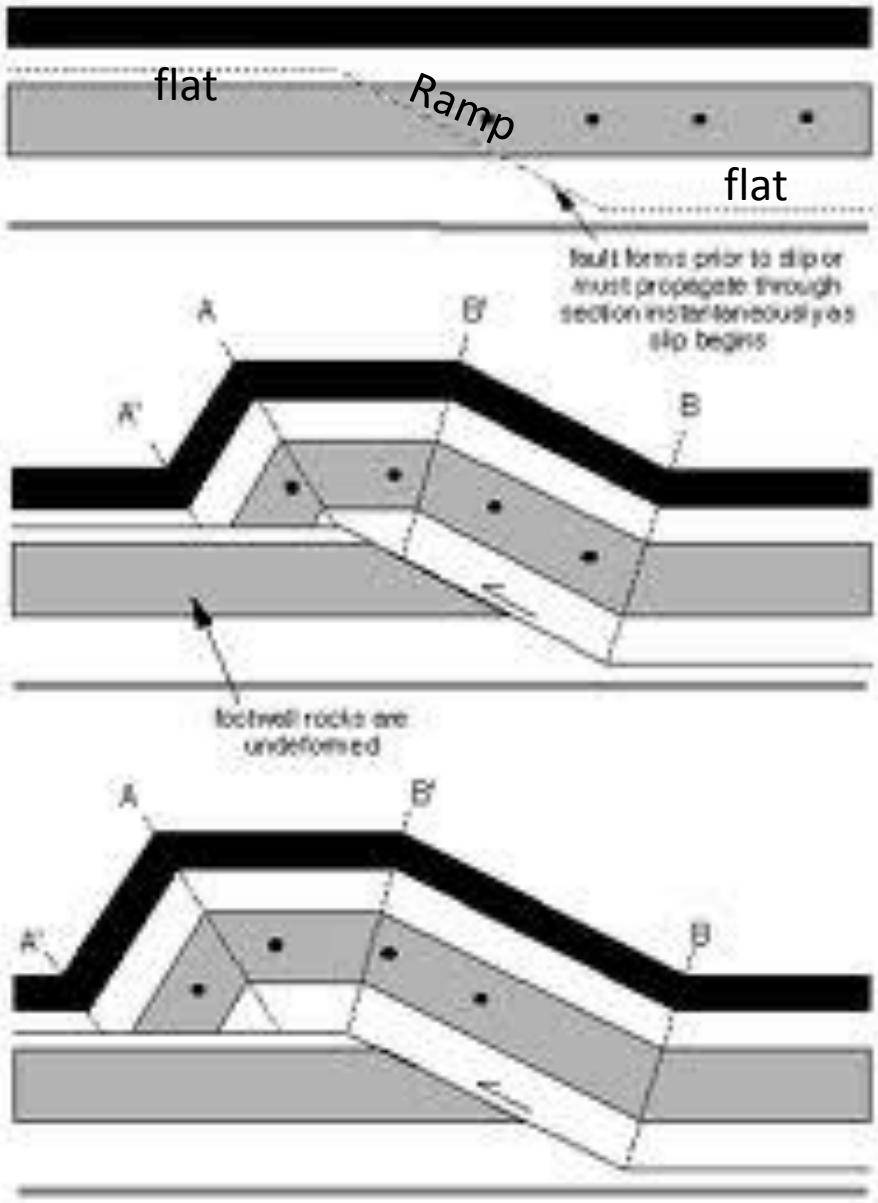
But bed orientation does not change

From internet

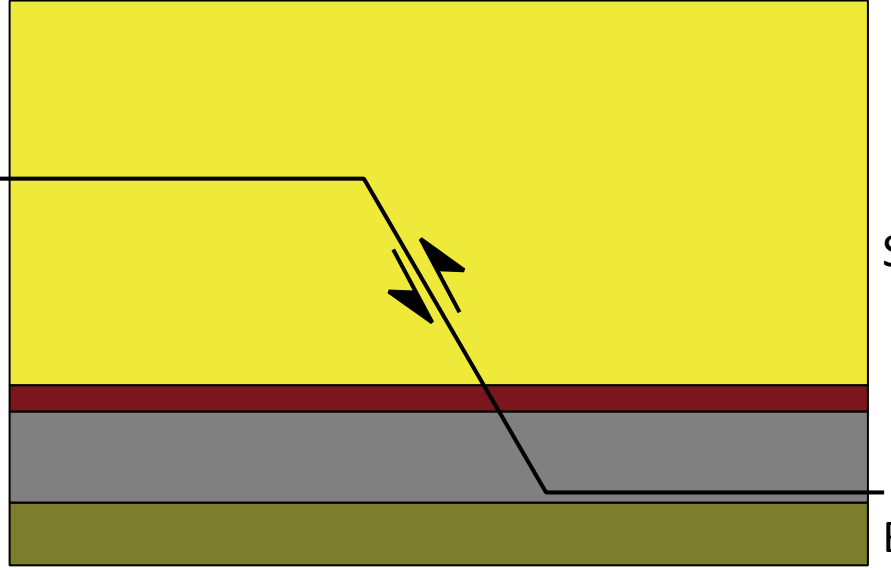


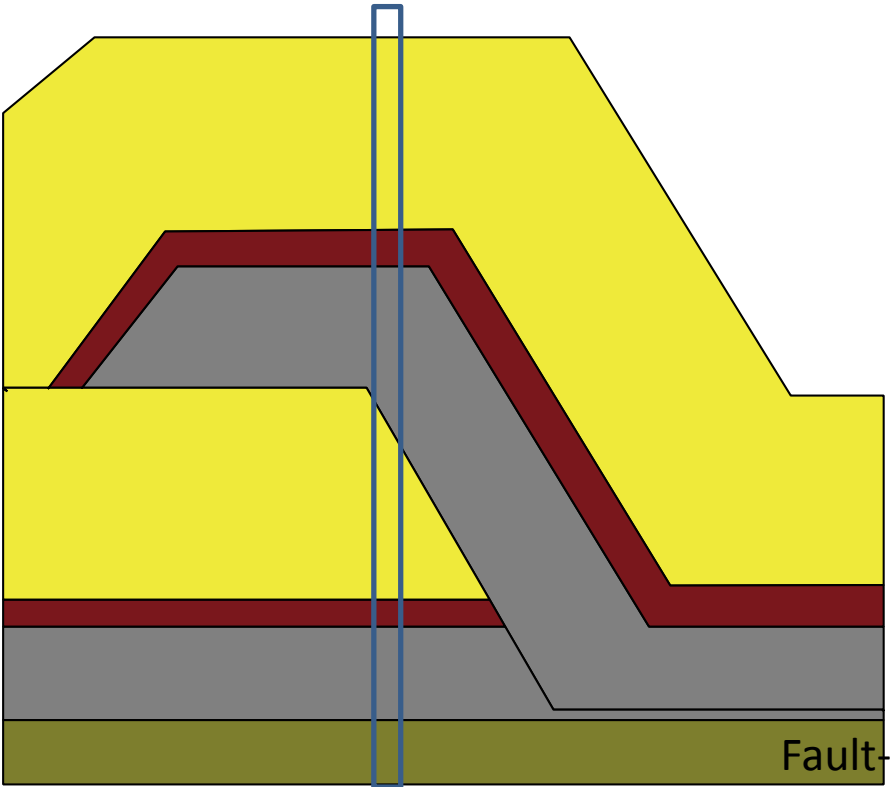
Orientation of bed varies

But sequence does not repeat

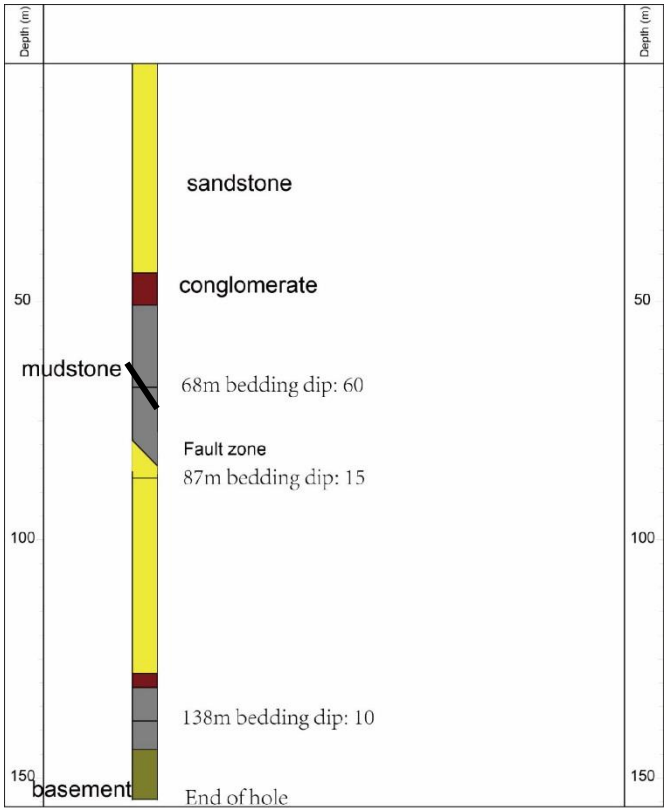


Fault-bend fold; From internet





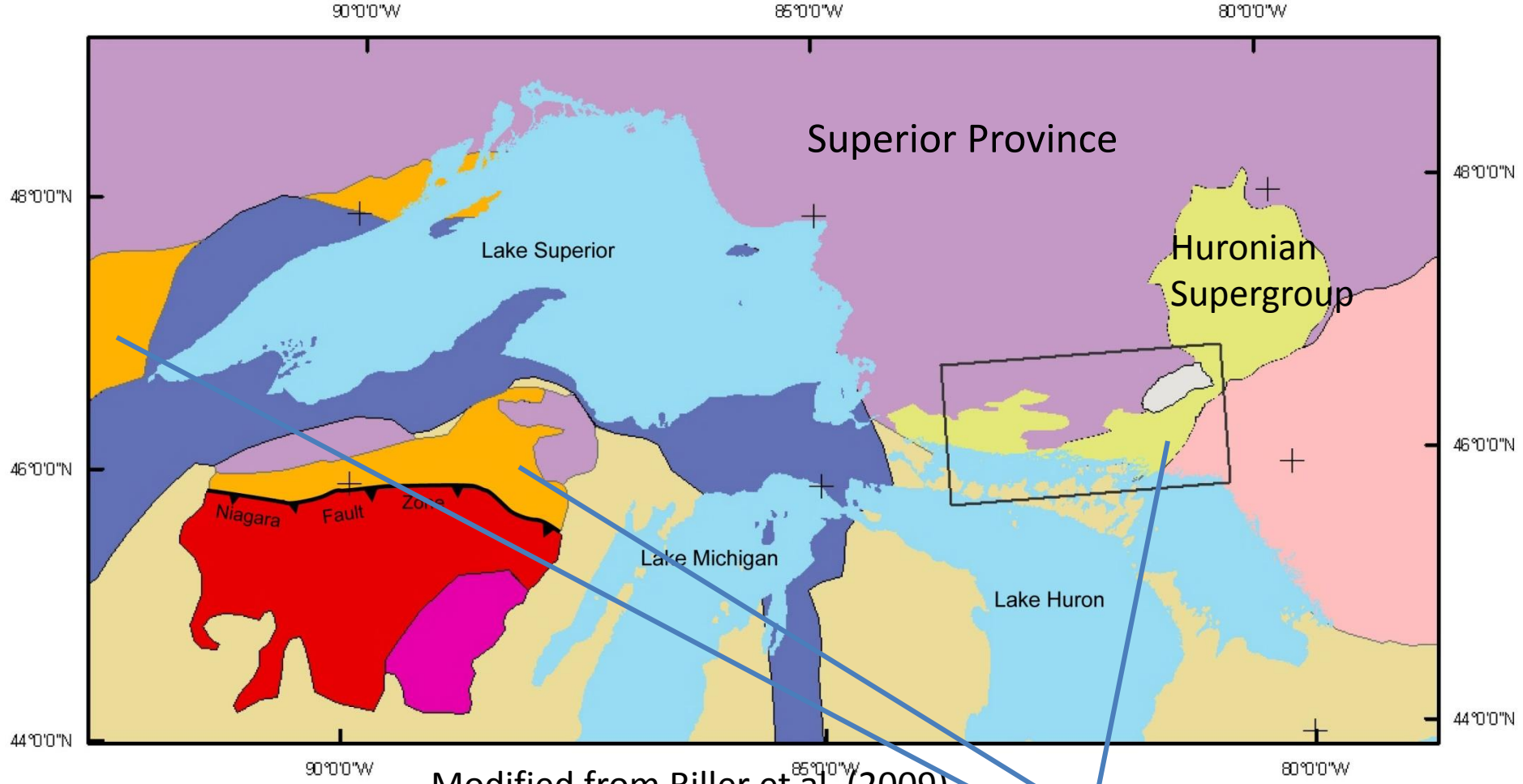
Fault-bend fold



Geological history

- History?

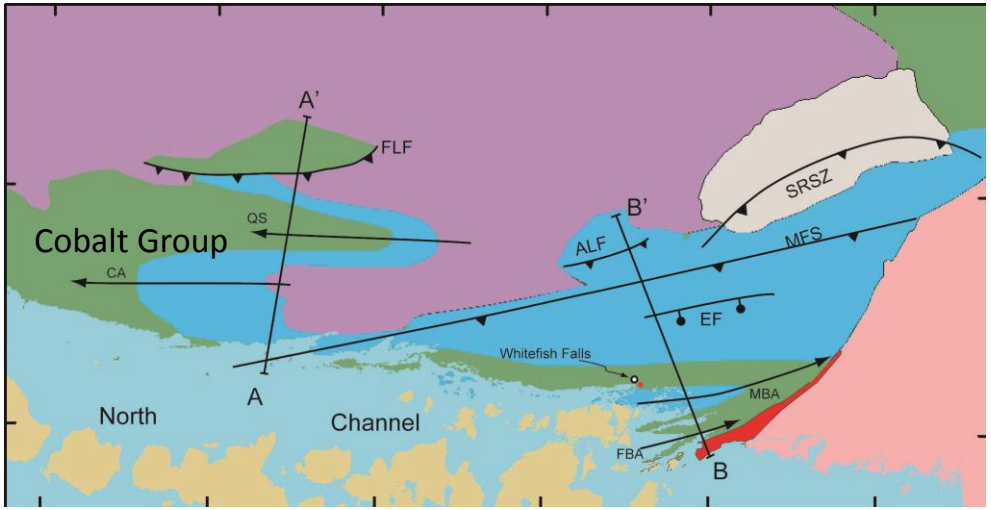
Structural analysis of folds and its tectonic significance: Southern Province



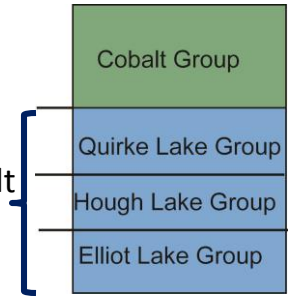
Modified from Riller et al. (2009)

1890-1830 Ma Penokean Orogeny

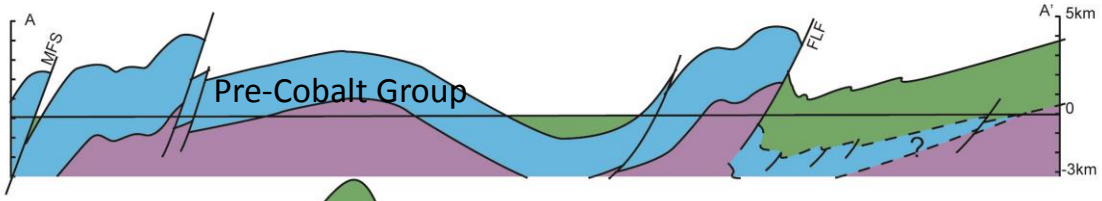
East-striking regional folds

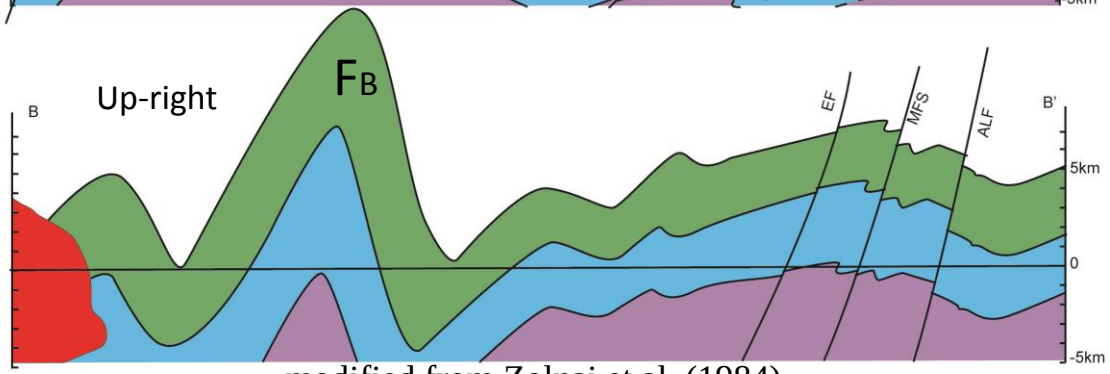


Huronian Supergroup



Pre-Cobalt Group



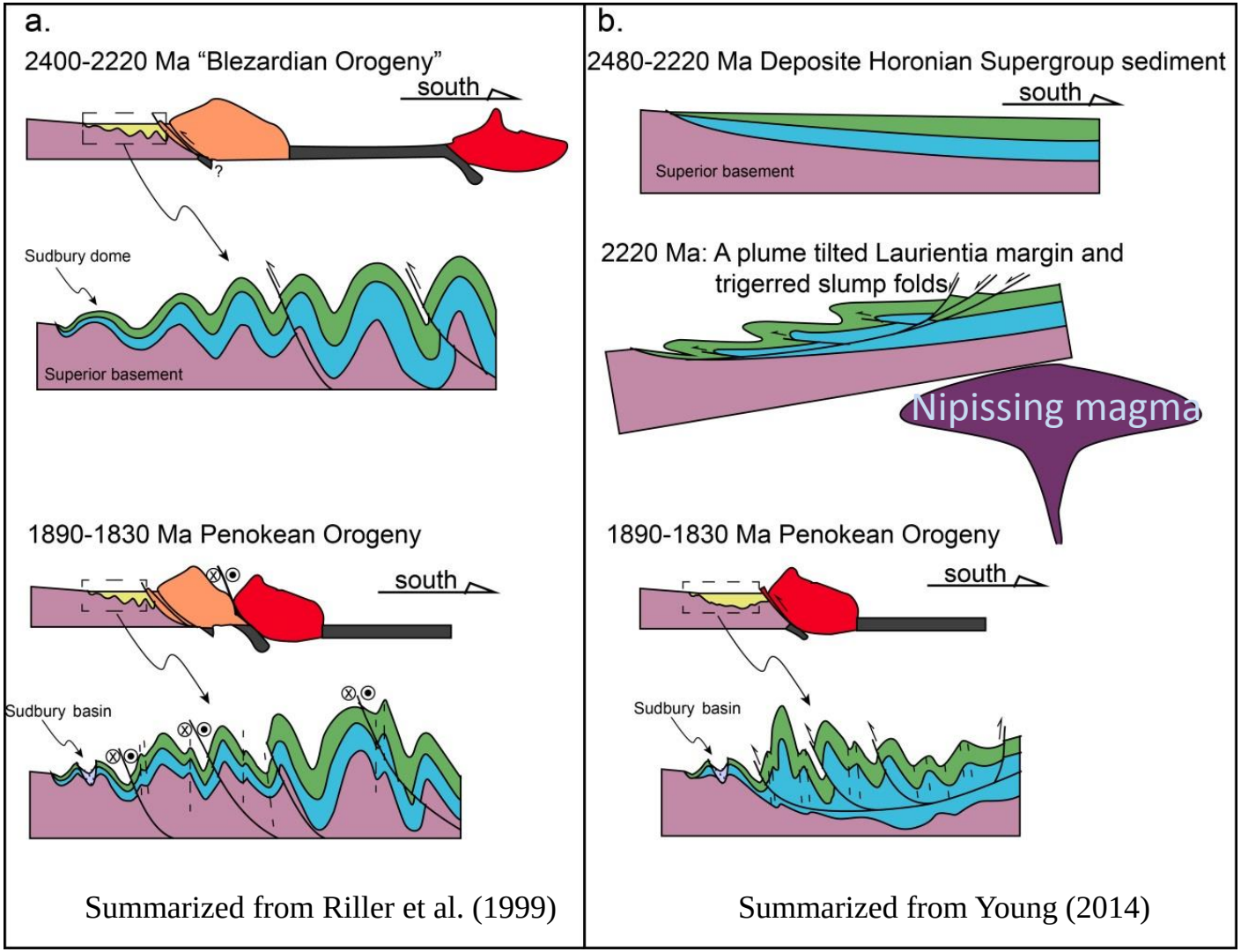


Penokean folds?
Other opinions….

modified from Zolnai et al. (1984)

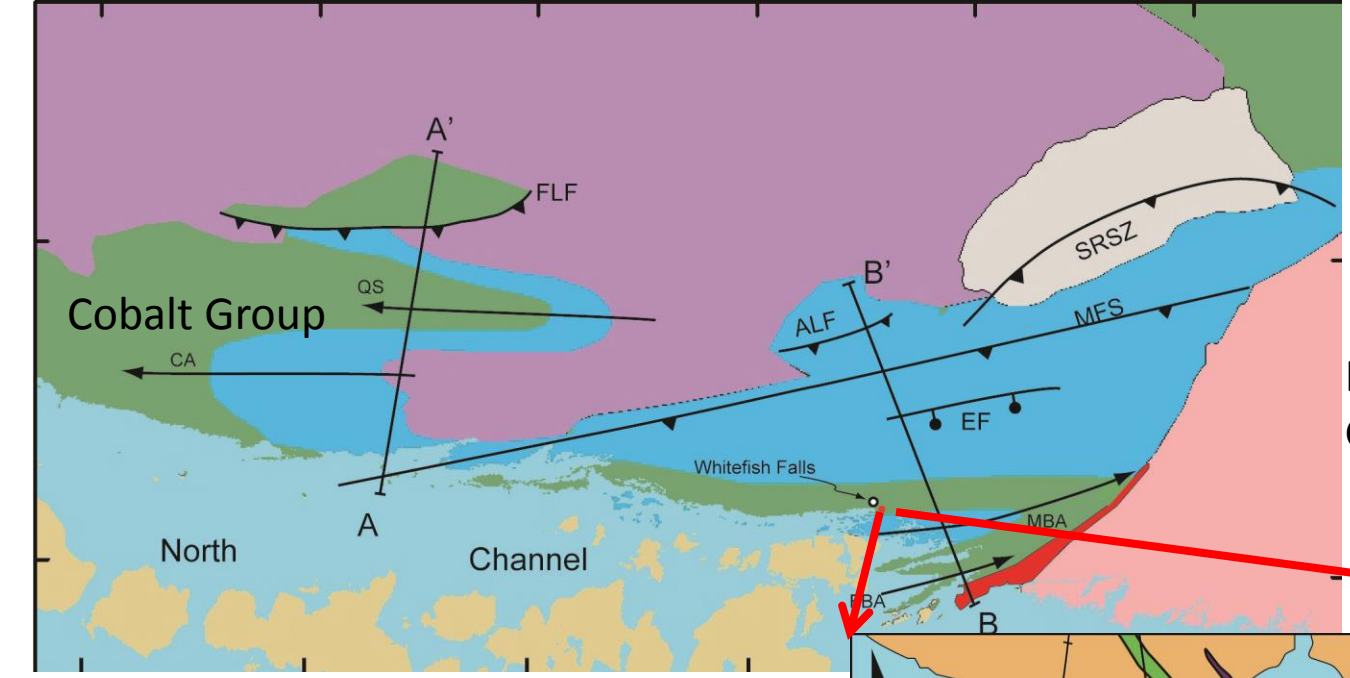
Folds wavelength:
tens of kms

Transpressional fault
Folds wavelength: kms
Axial plane cleavage

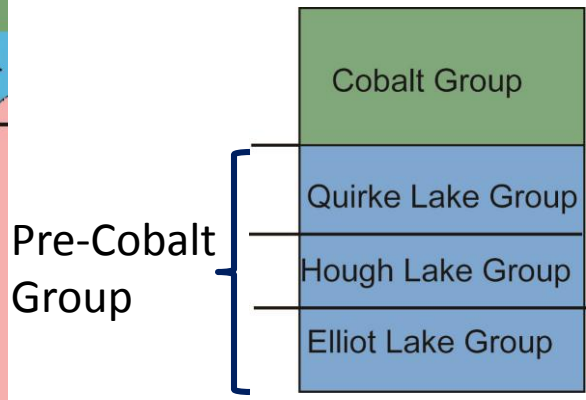


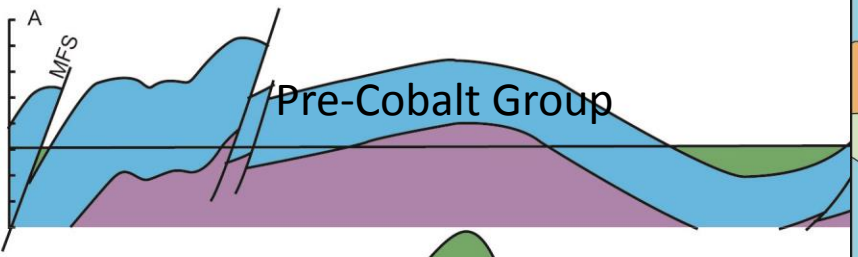
Summarized from Riller et al. (1999)

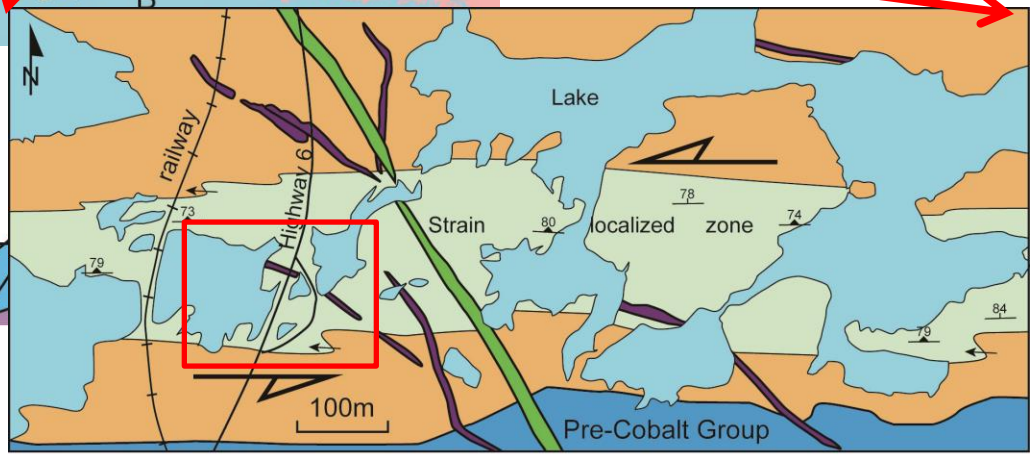
Summarized from Young (2014)



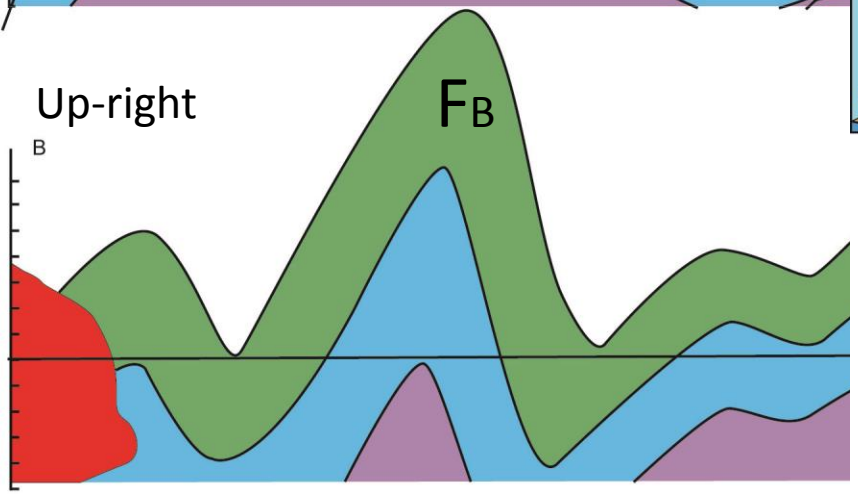
Huronian Supergroup







Up-right F_B



Gowganda sandstone, diamictite, and argillite

Gowganda laminated argillite

2220 Nipissing dike

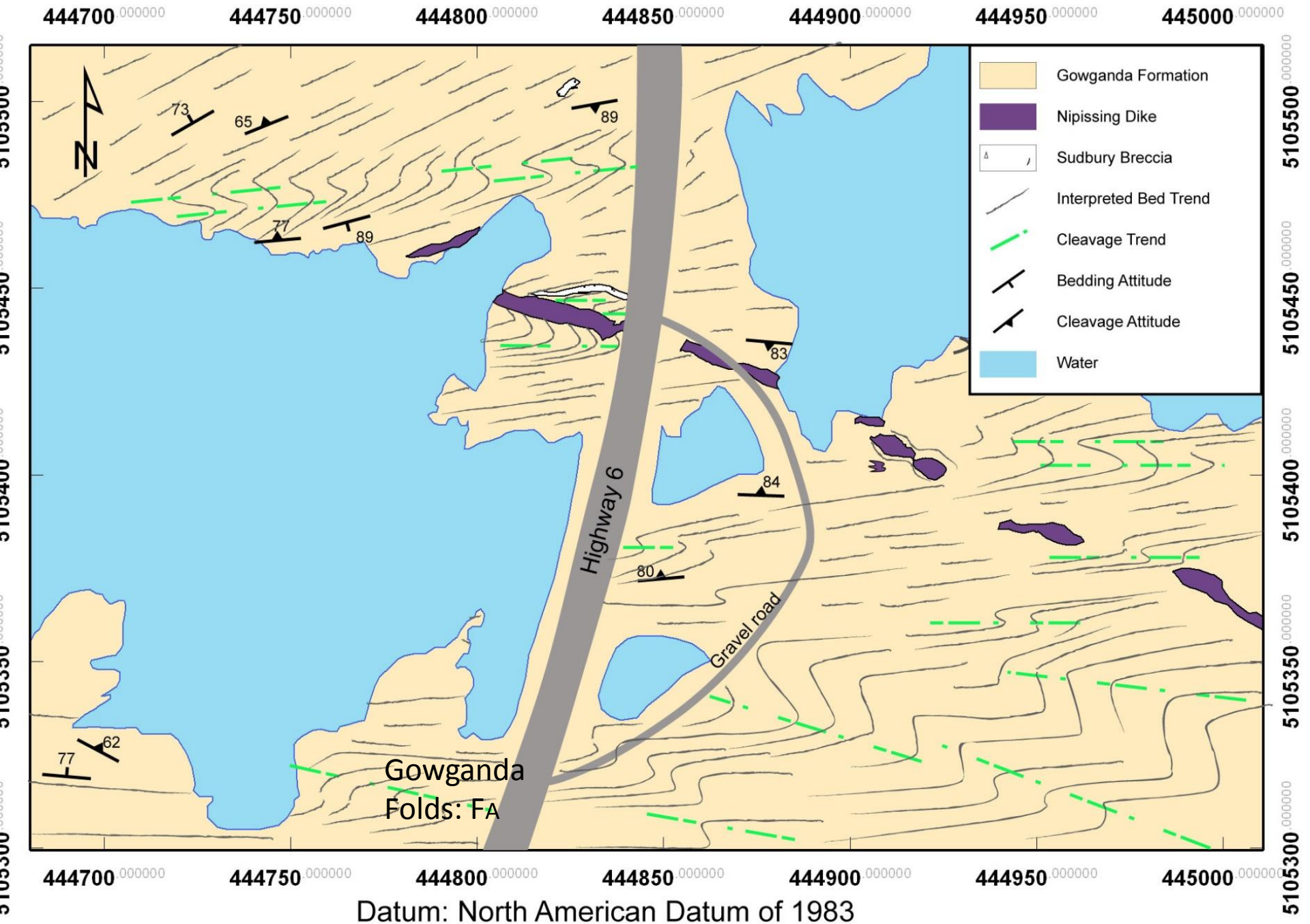
1238 Ma olivine diabase dike

Gowganda bedding

Cleavage

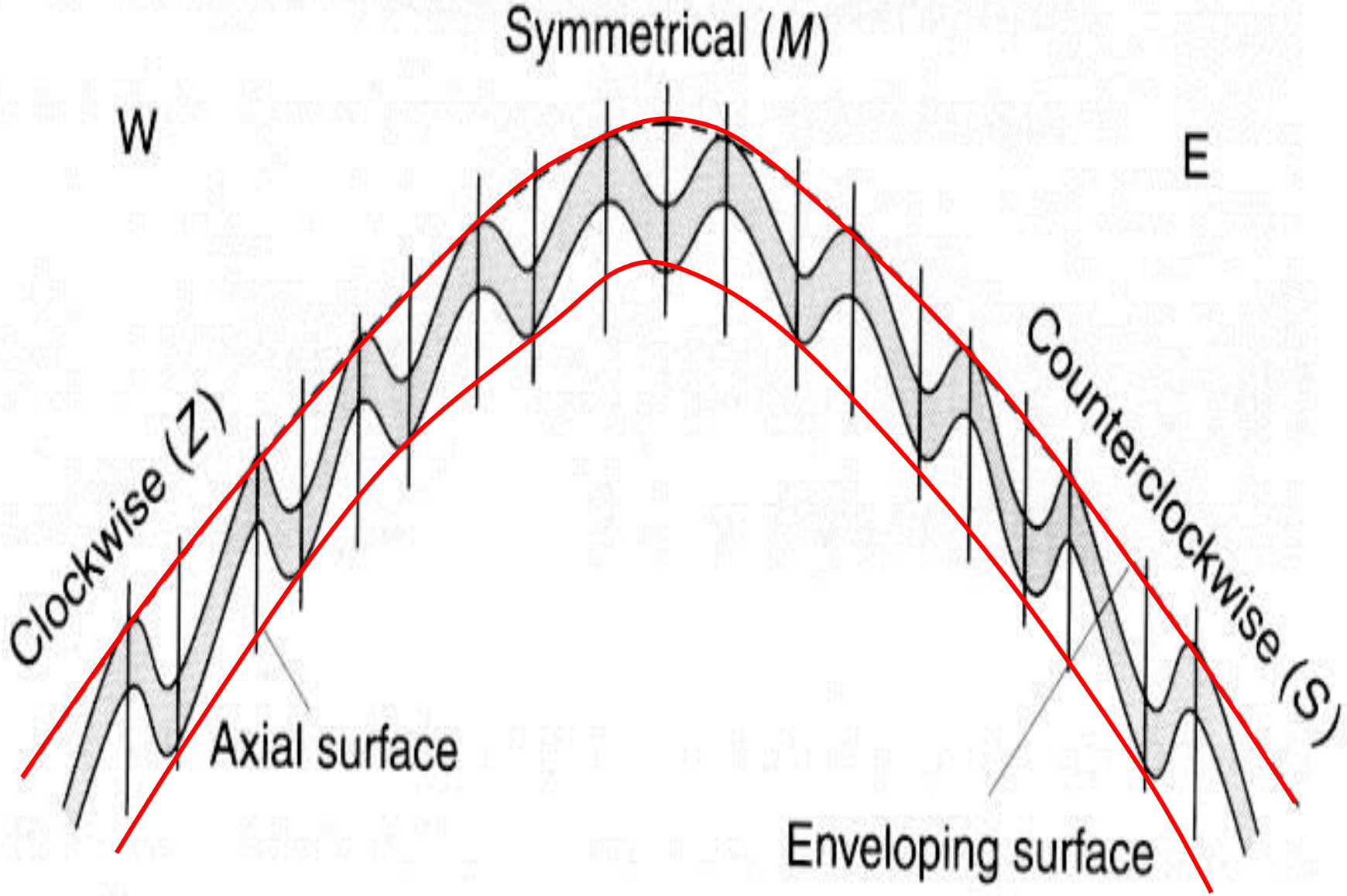
Fold axis

Gowganda Folds: F_A

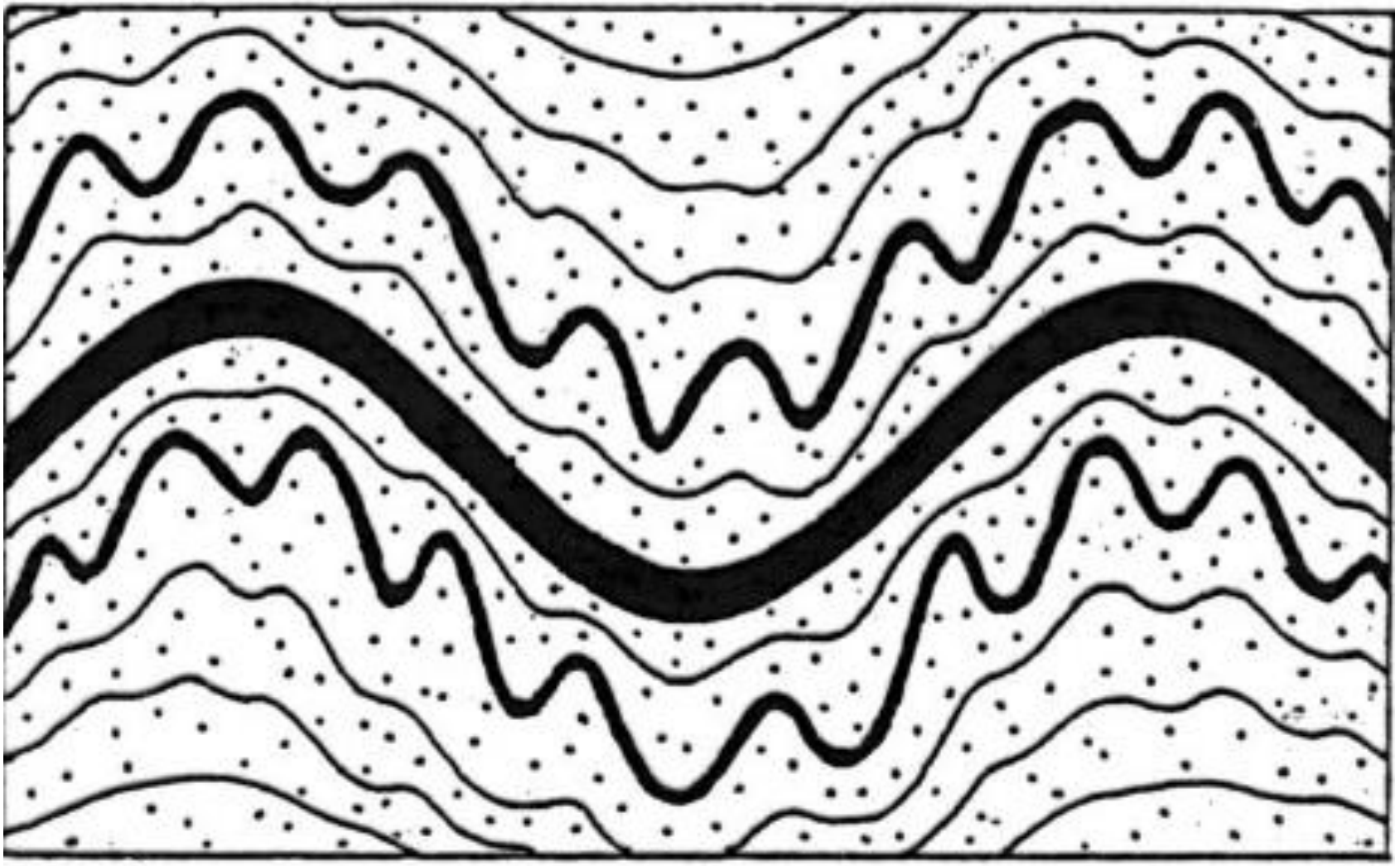


Datum: North American Datum of 1983

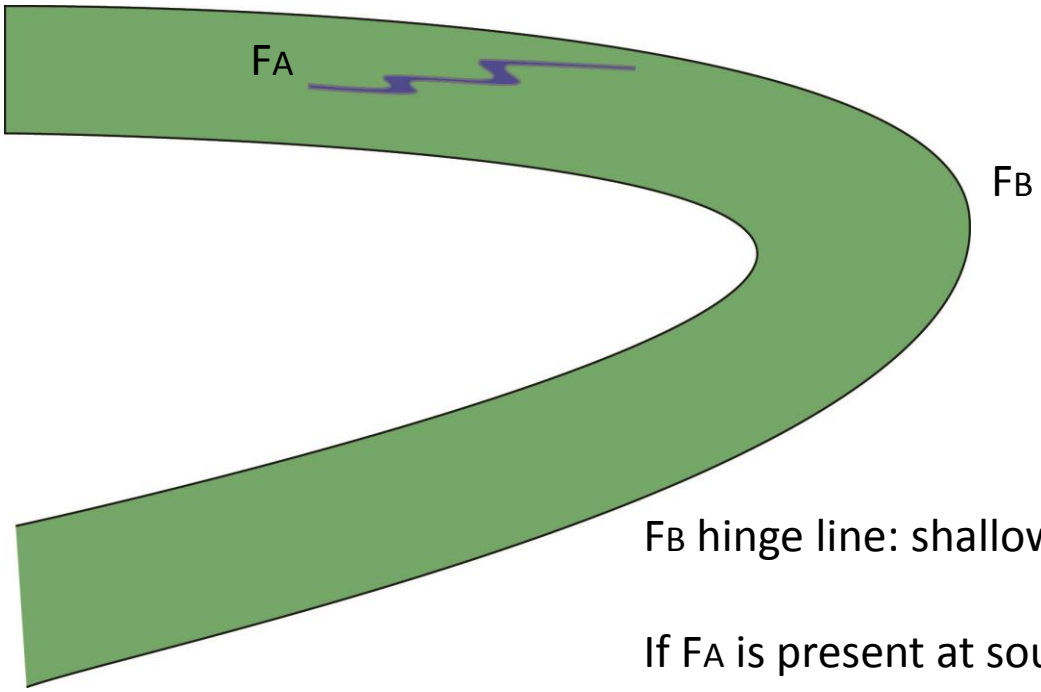
Projected coordinate system:UTM Zone 17N



Small folds: Parasitic folds of large red fold

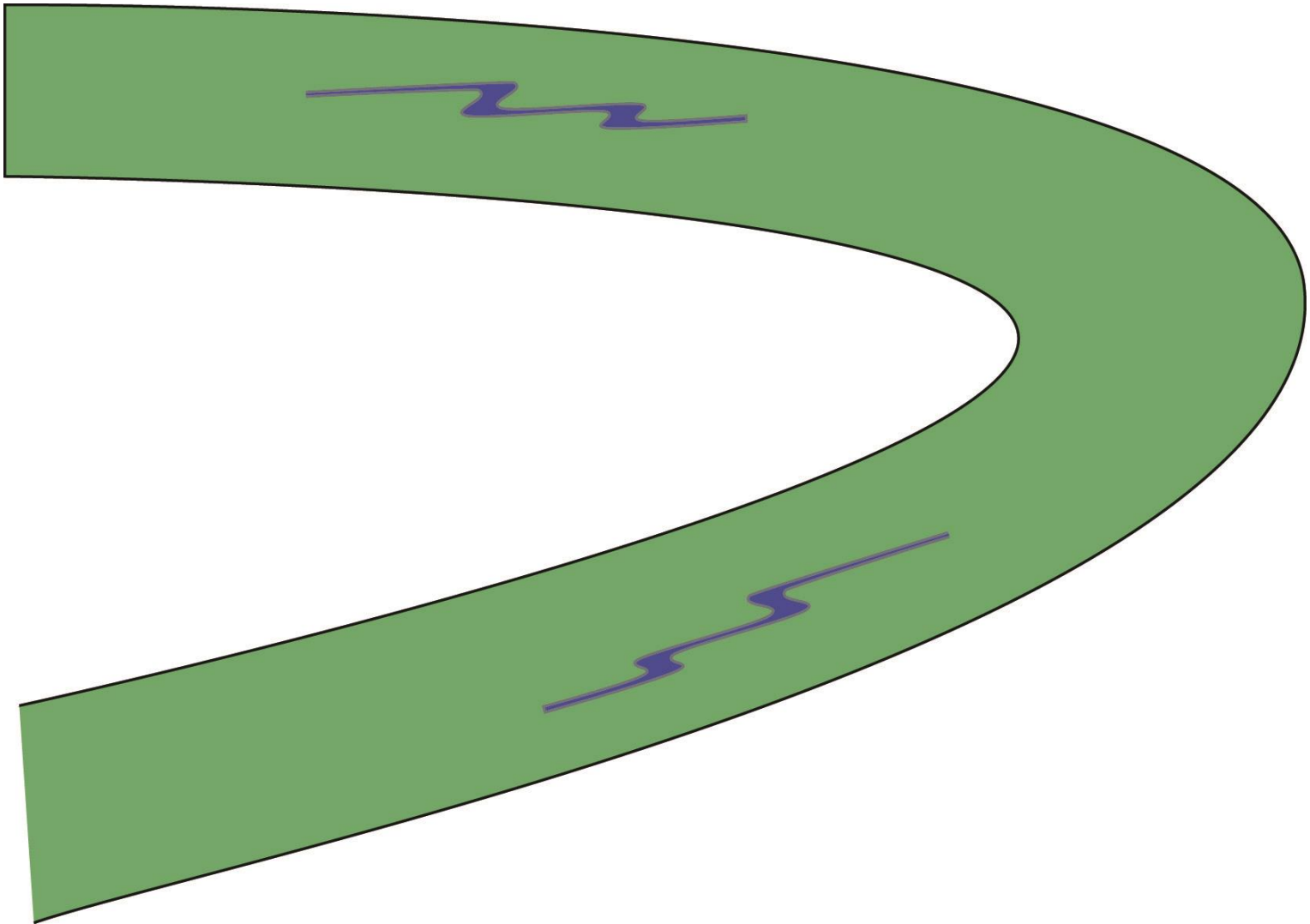


- Are F_A and F_B the same generation of folds?
- In another word, is F_A a parasitic fold of F_B?

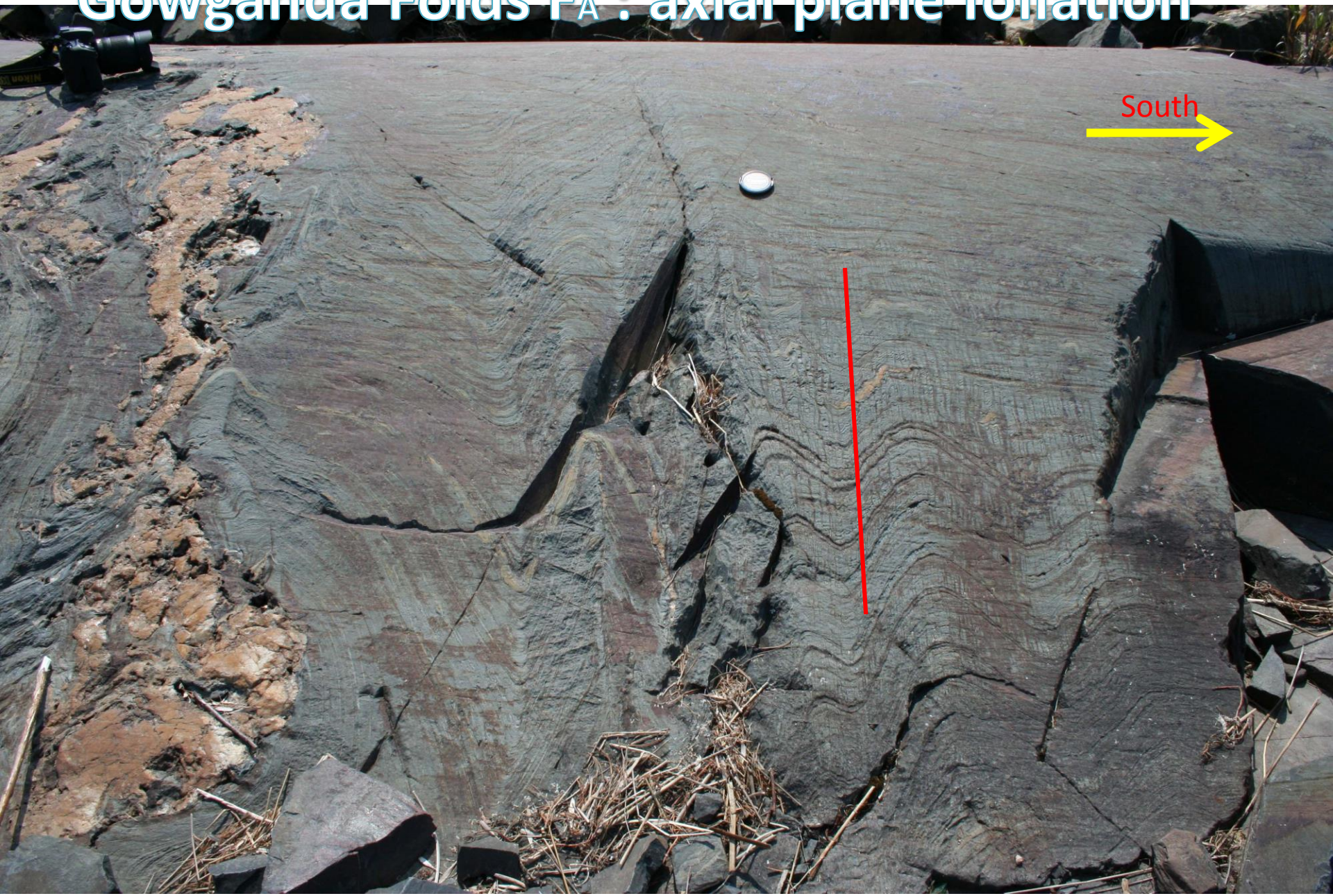


F_B hinge line: shallowly dipping

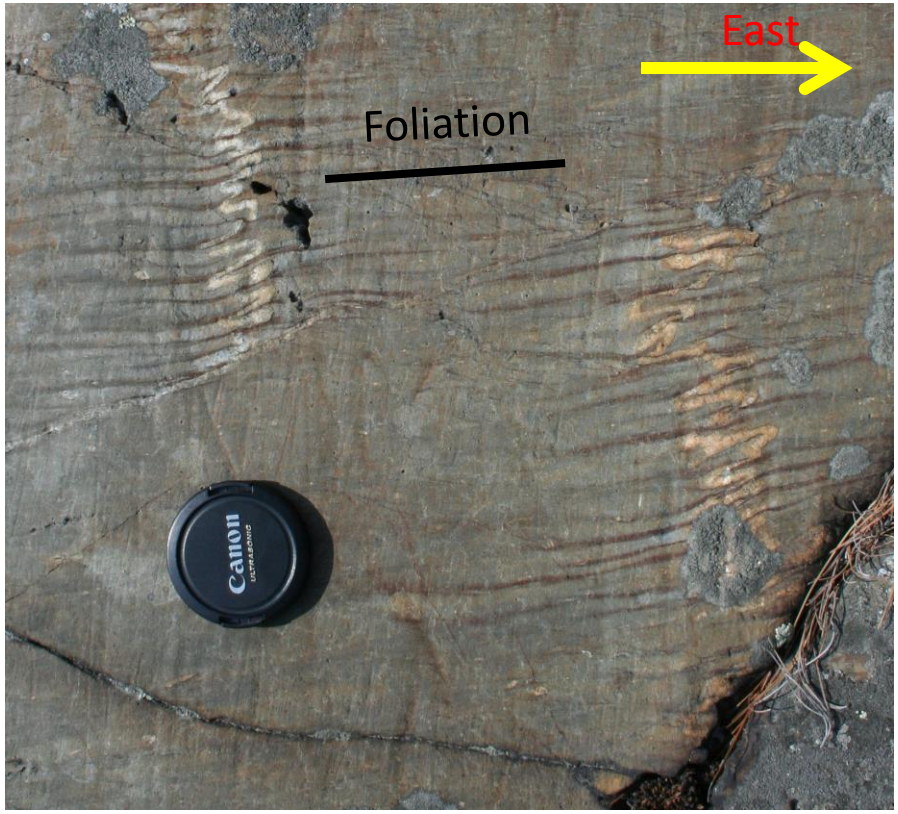
If F_A is present at south limb of F_B, what is its asymmetry?



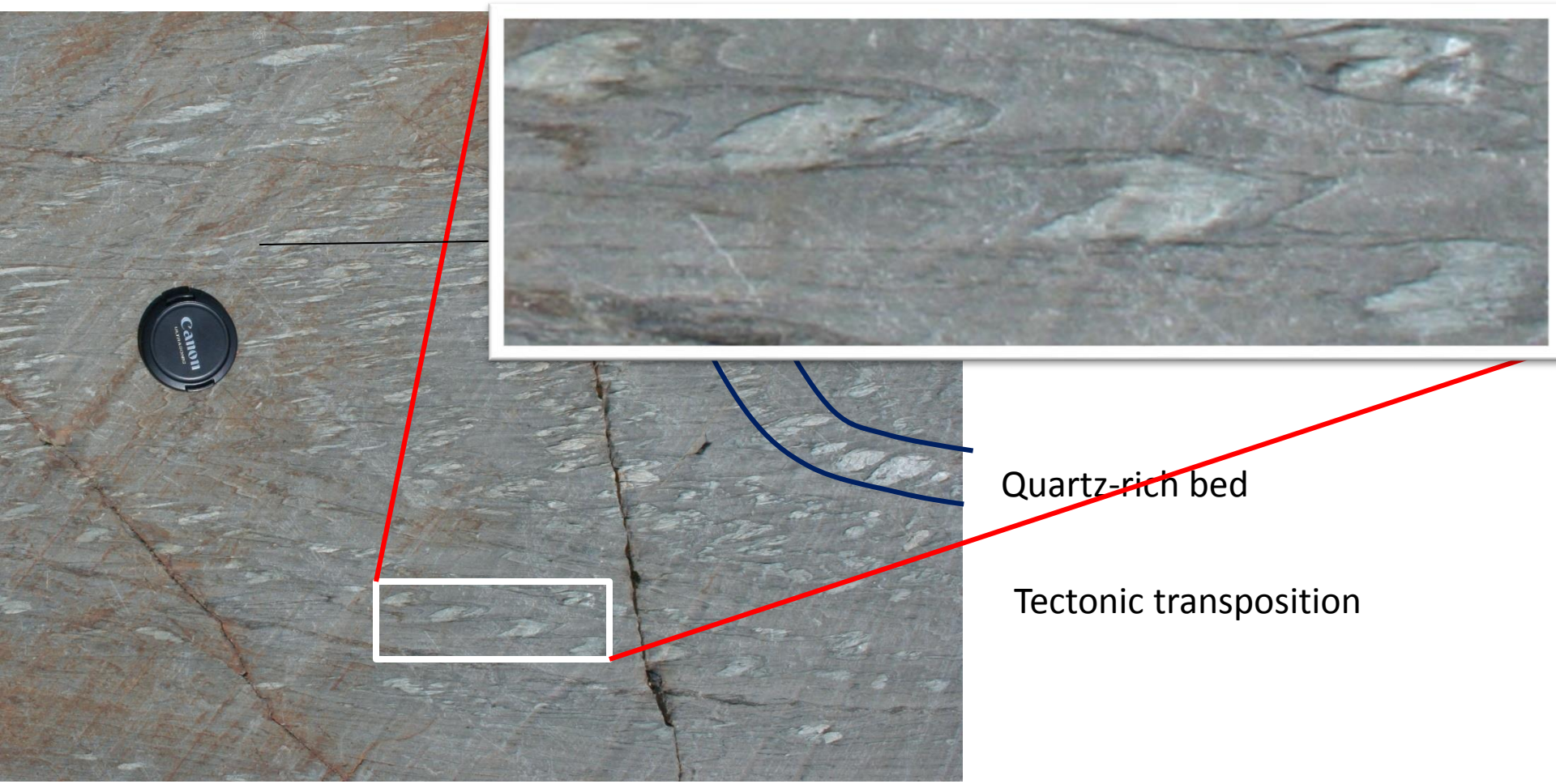
Gowganda Folds F_A : axial plane foliation

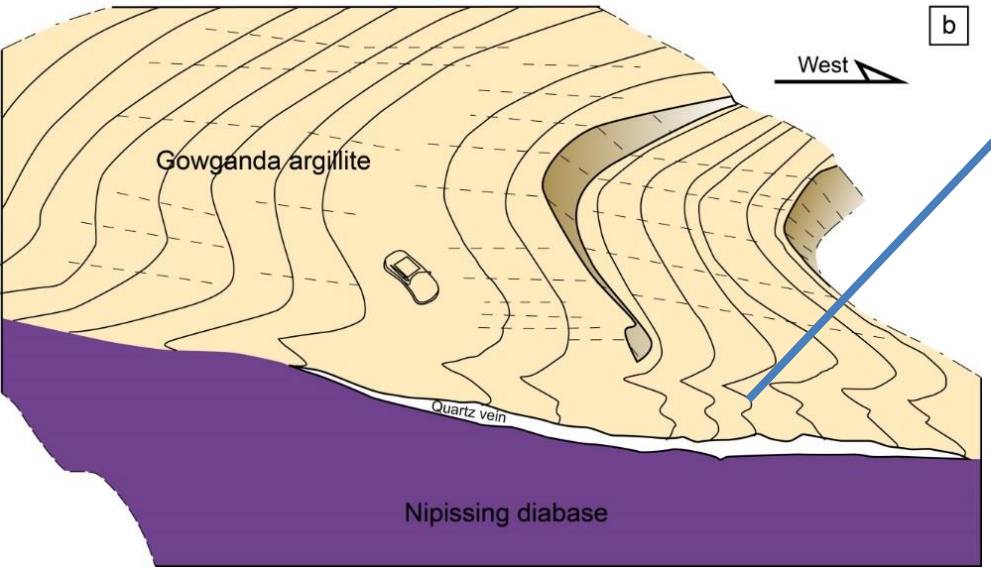


Gowganda Folds F_A : axial plane foliation



Tectonic folding

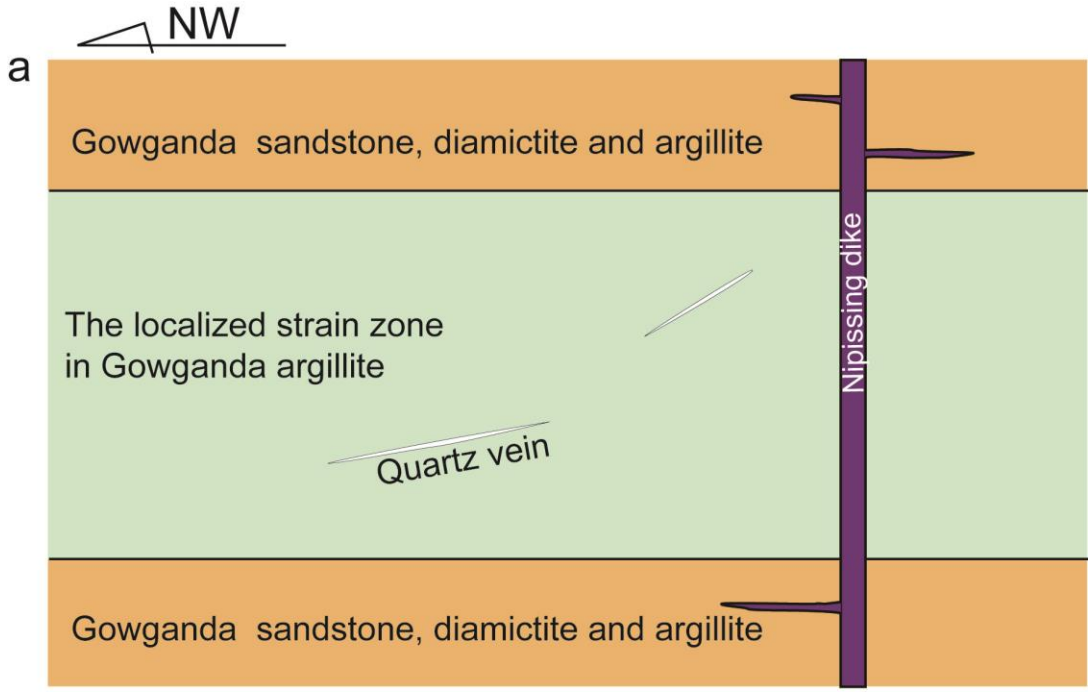




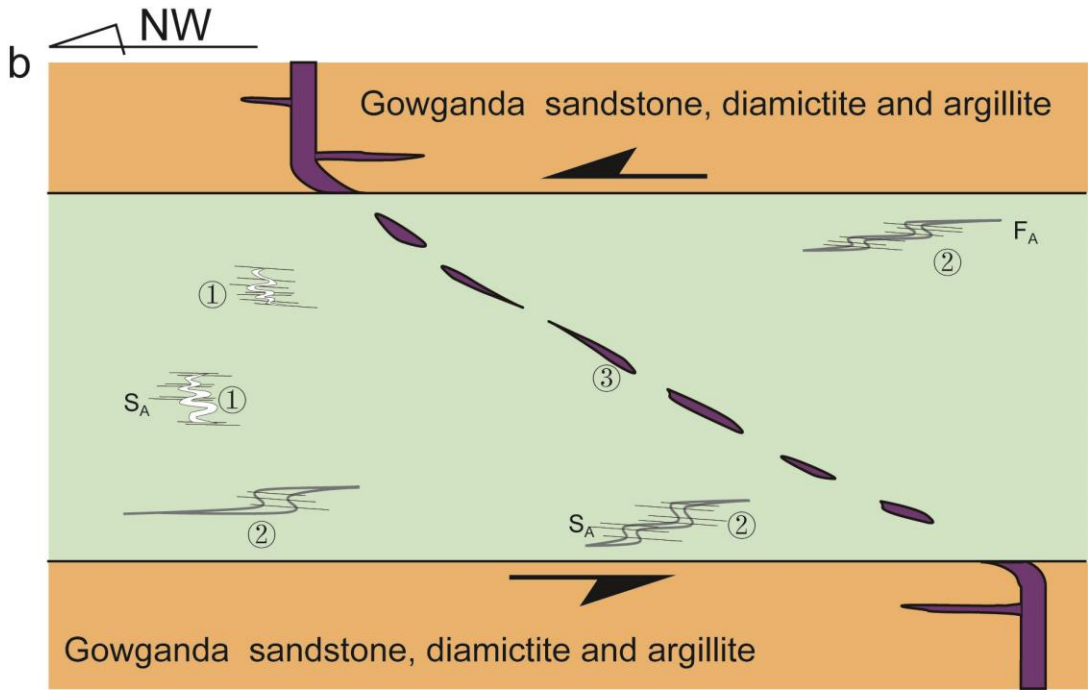
Did Nipissing dike intrude in the argillite before folding or after folding?

Within 30cm of the Nipissing dike;
Smaller interlimb angles;
Less harmonic;
Flanking folds;

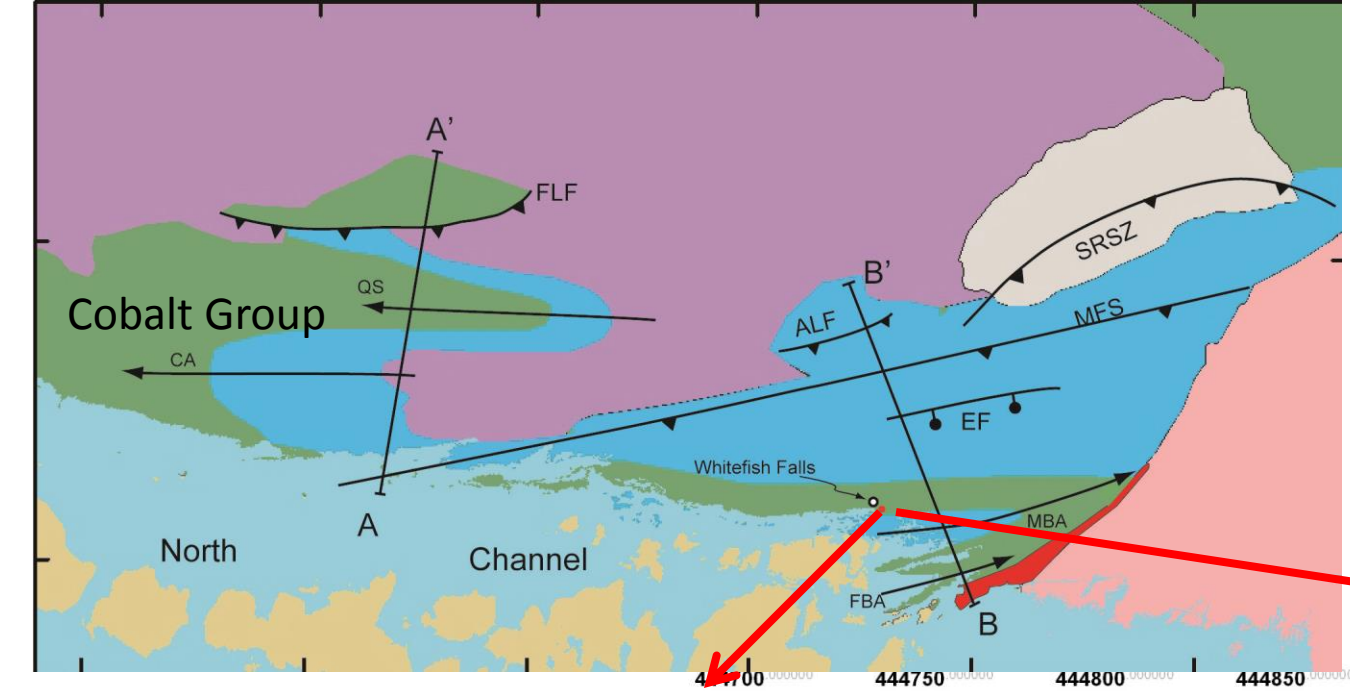
Dike was there when folding occurred

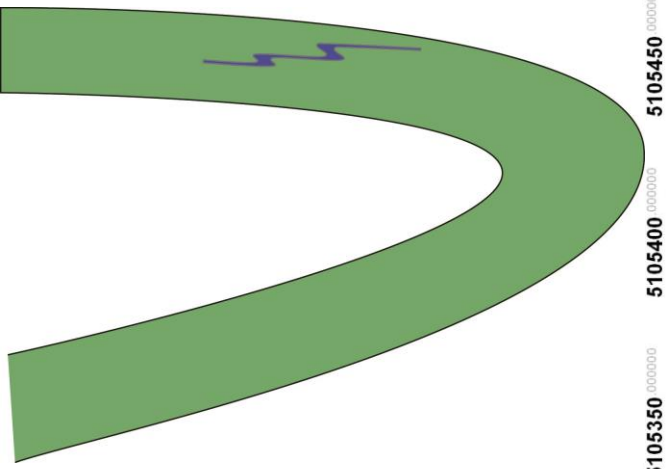


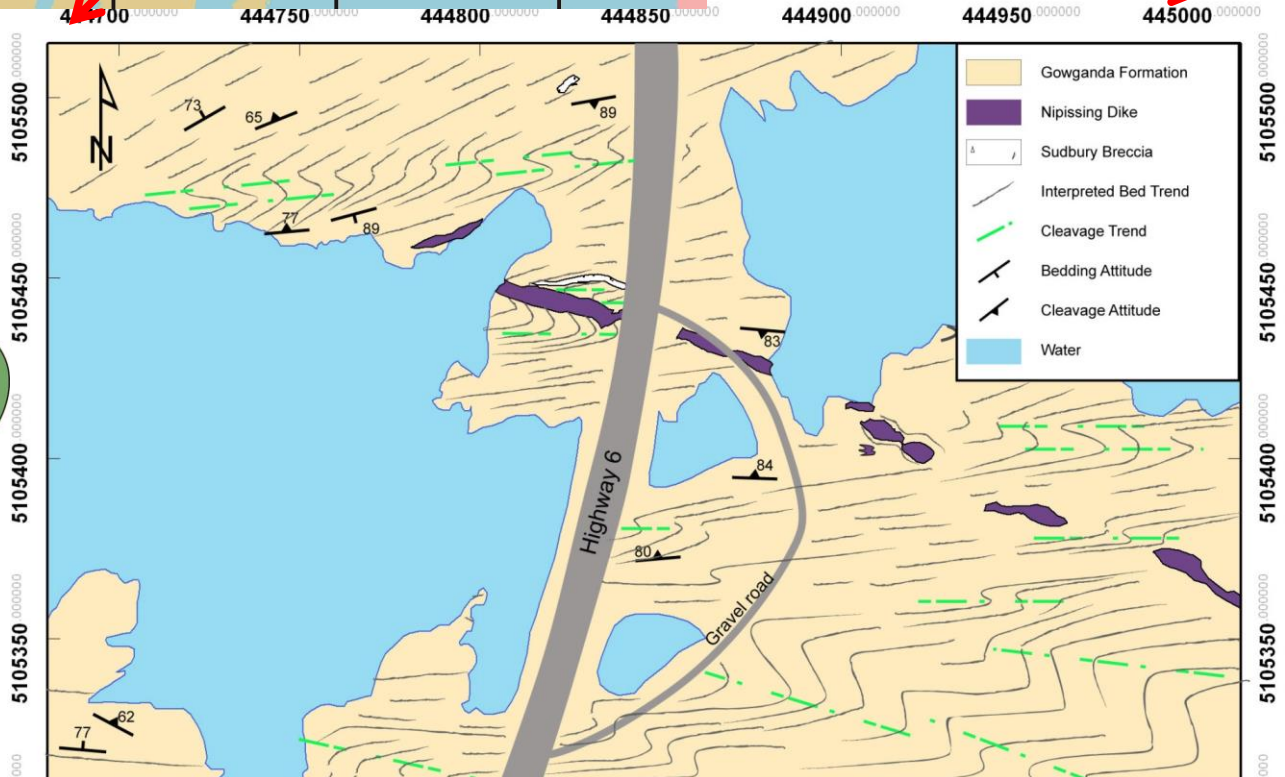
Interpretation for the development process of these structures



Bedding-parallel shearing within the strain localized zone


A'
FLF
QS
Cobalt Group
CA
B'
SRSZ
ALF
MFS
EF
Whitefish Falls
MBA
A
North
Channel
FBA
B




444700
444750
444800
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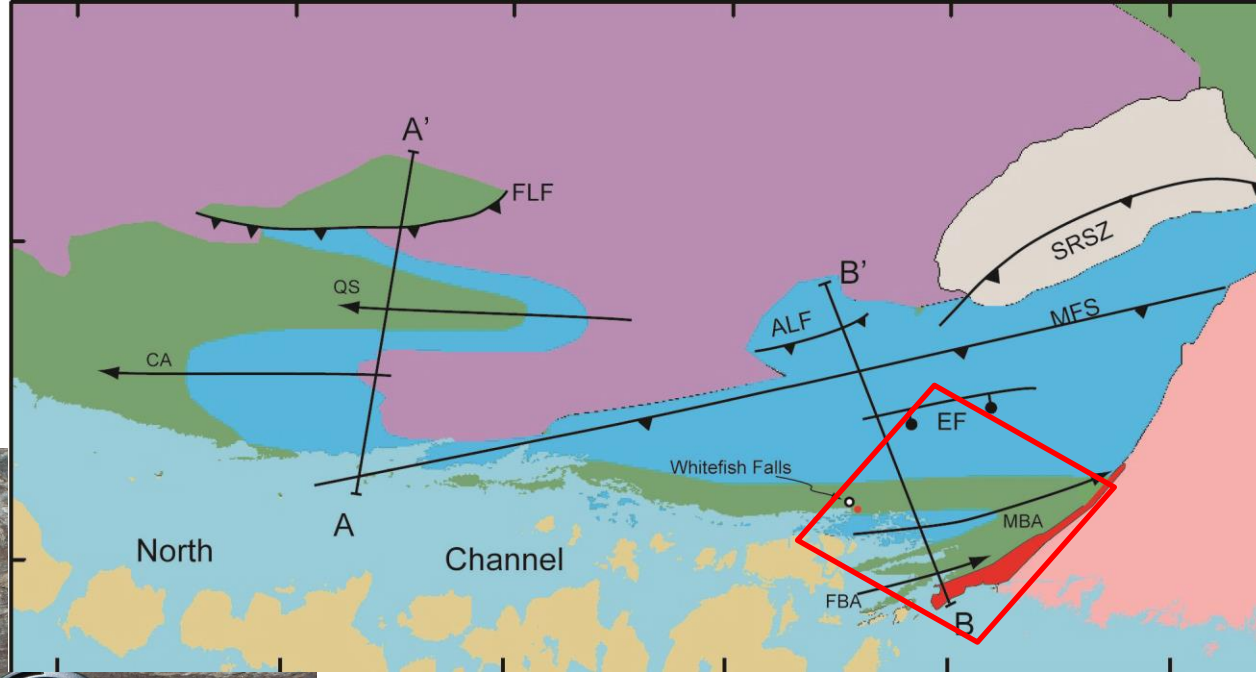
445000
5105500
5105450
5105400
5105350
N
73
65
89
77
89
83
84
80
62
77
Highway 6
Gravel road
Gowganda Formation
Nipissing Dike
Sudbury Breccia
Interpreted Bed Trend
Cleavage Trend
Bedding Attitude
Cleavage Attitude
Water

Gowganda Fold F_A: After 1850 Ma Sudbury Impact

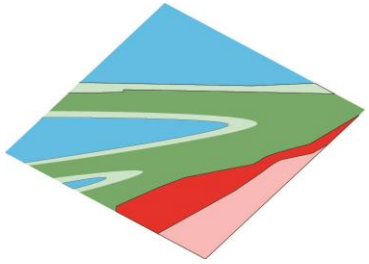


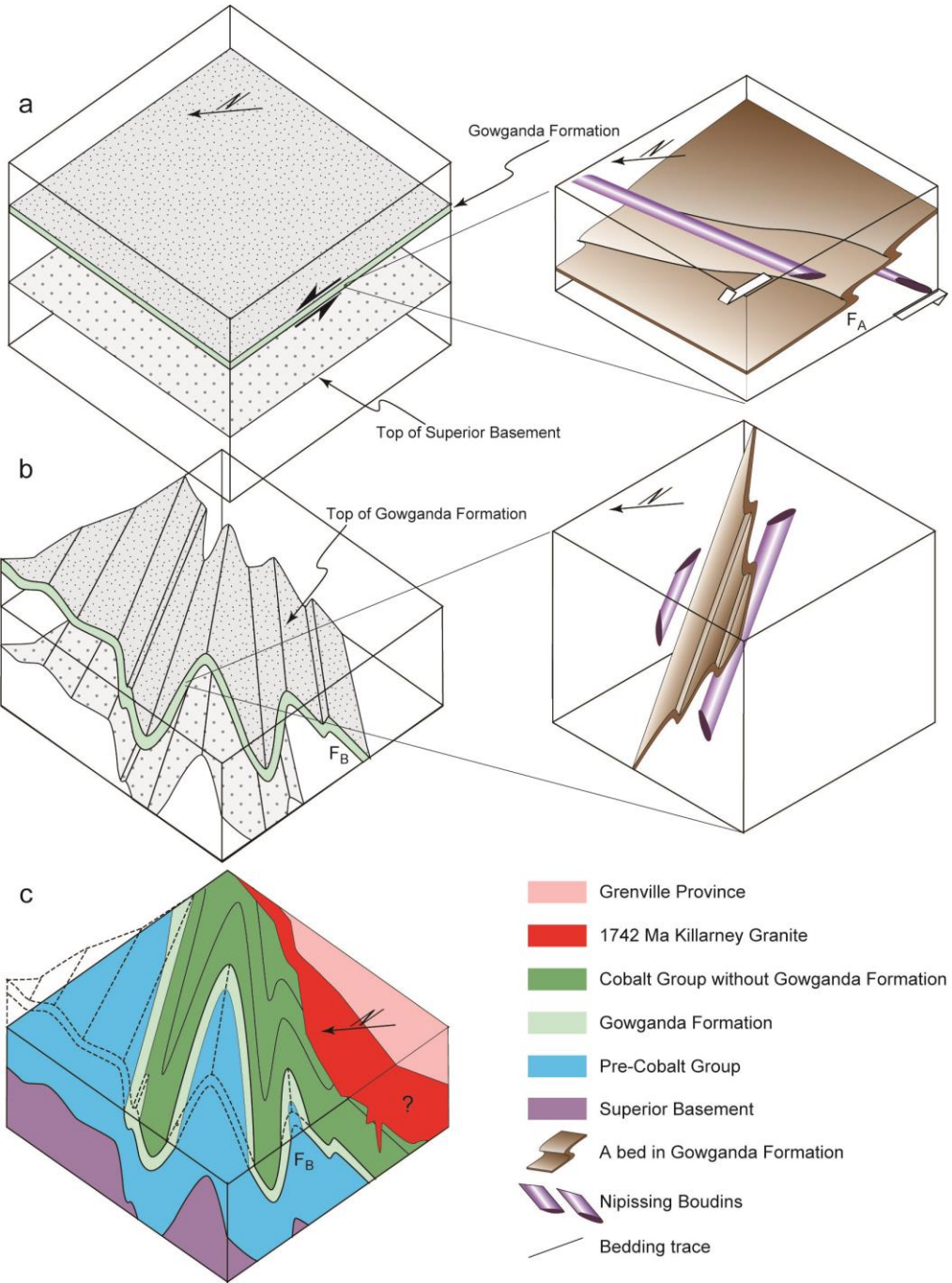
Regional Fold F_B: Before 1742 Ma granite

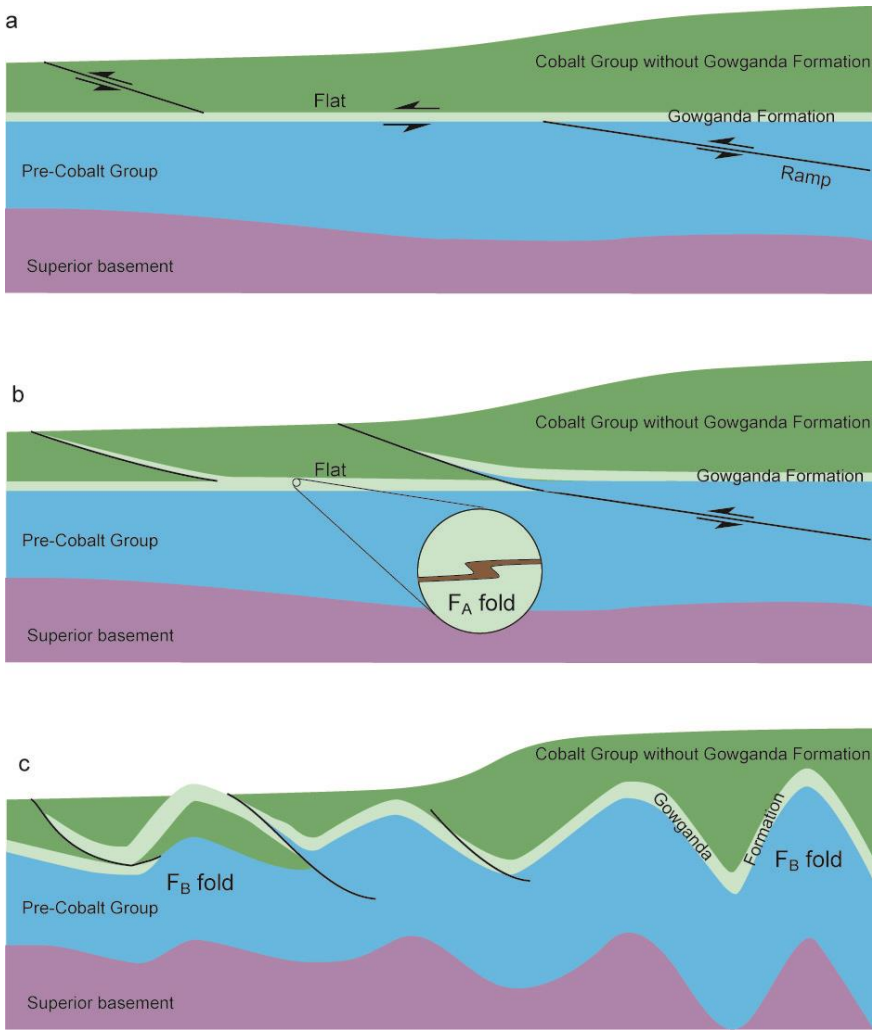
1850-1742 Ma

In Lake Superior area :
Penokean Orogeny 1890-1830 Ma

Here: 1850-1830 Ma







Tectonic Model: Fold-and-thrust belt

In the Penokean Orogeny between 1850 and 1830 Ma